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Electric power is laid into each of these buildings from the Clyde Valley Power Station, also water supply.
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 33.

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See Advertisement, page 27. 2584

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GENERATING SETS, Totally Enclosed, Three Crank Self-Lubricating Engine, with Complete Condensing Plant, by Allens, Pipes, Valves, Oil Separator, Etc., complete.
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Special designs only.
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See Advertisement page 58, Feb. 20. 2402

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Half price. Send for list.
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WILSON, CALDWELL & TAIT.
79, West Regent Street,
Glasgow. H 246

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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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The Central Argentine Rail-

WAY LIMITED (Head Office, 3a, Coleman Street, London, E.C.2), begs to notify ALL WHOM IT MAY CONCERN that a person who describes himself as "FRANKL" or "F.L." "NEHER" is unknown to the Company and it follows that he is entirely without any authority to invite or receive Tenders for any goods on behalf of the Company or in any way to represent himself as an Engineer of, or holding a position in any other capacity in connection with, the Company. H 308

Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 788

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2676

TENDERS.

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, invites

Tenders for :—

1. STEEL DIVISION PLATES for India Rubber Springs for covered wagons.
2. LOCOMOTIVES. No. 14.
3. RAILWAY GOODS BRAKE VANS. No. 13.

Tenders due on the 10th March, 1925, for No. 1, and on the 20th March, 1925, for Nos. 2 and 3.
Tender Forms obtainable from above. H 356

THE URBAN DISTRICT COUNCIL OF HOYLAKE AND WEST KIRBY.

Tenders are Invited for the

PURCHASE OF SCRAP WROUGHT AND CAST IRON, now lying at the Council's Depot, near Hoylake Station, London Midland & Scottish Railway.

The prices quoted must be at per ton for mixed scrap wrought and cast iron.

The Council will be willing to load the scrap metal into railway waggons for purchasers.

Tenders, endorsed "Scrap Iron," which must be accompanied by Banker's reference, to be delivered through the post not later than 10th day of March, 1925, and addressed to the CHAIRMAN OF THE FINANCE COMMITTEE, Town Hall, Hoylake.

The Council do not undertake to accept the highest or any Tender.

Town Hall,
Hoylake,
via Birkenhead.
February, 1925. H 350

EDMONTON UNION.

TO ENGINEERS AND CONTRACTORS.

THE GUARDIANS OF THE EDMONTON UNION invite

Tenders for taking down the

TOWER TANKS at CHASE FARM SCHOOLS, RIDGEWAY ROAD, ENFIELD in the County of Middlesex, and the erection of New Tanks and sundry works in connection with the same.

A copy of the Specification and Form of Tender can be obtained from J. C. S. MUMMERY, A.R.I.B.A., 34, Bloomsbury Square, W.C.1, where the drawings and form of contract can be seen.

Tenders must be on the form supplied, enclosed in a sealed envelope, endorsed "Tender for Tanks," and delivered to the Clerk to the Guardians of the Edmonton Union, 77, Bridport Road, Upper Edmonton, N.18, not later than Nine o'clock a.m., on Wednesday, 25th March, 1925.

The Guardians will not bind themselves necessarily to accept the lowest or any Tender.

(Signed) EDWIN RIDLEY,
Clerk to the Guardians. H 309

COUNTY BOROUGH OF STOKE-ON-TRENT.

ELECTRICITY DEPARTMENT.

(CONTRACT No. 2308.)

Tenders are Invited for :—

STEAM PIPING, with Welded Flanges, Valves.
STEAM TRAPS, etc. (Section 1.)
WATER PIPES, VALVES, etc., of Cast Iron. (Section 2.)

Tender Forms and Specifications obtainable from Borough Electrical Engineer, St. Peter's Chambers, Stoke-on-Trent, on deposit of £2.

Tenders to be delivered March 10th, 1925, to
B. B. SHARPLEY,
Town Clerk.

Town Hall,
Stoke-on-Trent.
February 23rd, 1925. H 339

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, E.C.2, invite

Tenders for :—

VERTICAL BOILERS .. Fee 5/-.

Tenders are due by Eleven a.m., on 10th March, 1925. Tender forms obtainable at above address. Fees not returnable. H 370

STEAM NAVVY FOR SALE.

Tenders are about to be

Invited for the purchase of a RUSTON STEAM NAVVY at Longmoor Camp, Hants., particulars of which are as follows :—

Bucket capacity 2¼ cu. yards.
Rail Gauge 4 ft. 8½ in.
Working Gauge 9 ft. 3 in.
Wheelbase 9 ft. 11 in.
Total weight about 60 tons.

Forms of Tender can be obtained on application to THE DIRECTOR OF ARMY CONTRACTS (D.C. Sales), Caxton House West, Tothill Street, S.W. 1. H 289

METROPOLITAN WATER BOARD.

PROVISION OF 5 TON STEAM CRANE—BATTERSEA.

The Metropolitan Water Board invite

Tenders for the Supply, Test-

ING and Setting to Work of a STEAM DRIVEN LOCOMOTIVE SHUNTING JIB CRANE of 5 tons capacity at their Works in Kirtling Street, Battersea Park Road, S.W.

Tenders must be made on the official forms which may be obtained on and after Thursday, 19th February, 1925, from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1. by personal application (room 156), or upon forwarding a stamped addressed brief envelope.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk, Metropolitan Water Board, New River Head 173, Rosebery Avenue, E.C.1," and endorsed "Tender for Crane," must be delivered at the Offices of the Board (Room 122) not later than 11 a.m., on Tuesday, 3rd March, 1925.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue, E.C.1.
17th February, 1925. H 278

METROPOLITAN ASYLUMS BOARD.

TO ENGINEERS.

The Board invite separate

Tenders for :—

A INSTALLATION of 144 TUBE ECONOMISER.
B INSTALLATION of NEW CONTINUOUS DRYING MACHINE.
C ENGINEERING WORK for New Central Boilerhouse.
D REVISION of LAUNDRY ENGINEERING Arrangements.
E INSTALLING ELECTRIC LIGHT and POWER WIRING in Boilerhouse and Laundry.
F COVERING BOILERS, STEAM, FEED and SUCTION MAINS, etc., with Non-conducting Composition,

at the South Western Fever Hospital, Landor Road, Stockwell, S.W.9, each in accordance with the Specification and Drawings prepared by Mr. T. C. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specifications Drawings, and Forms of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4. on and after Ten a.m., on Monday, 2nd March, 1925, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, March 25th, 1925.

G. A. POWELL,
Clerk to the Board. H 335

URBAN DISTRICT COUNCIL OF HAVANT (Hants).

EXTENSION OF MAIN DRAINAGE WORKS OF HAVANT.

UNEMPLOYMENT RELIEF WORKS.

General Contract No. 2.

The Urban District Council of Havant invite

Tenders from Responsible

and Experienced Contractors for the CONSTRUCTION of the WORKS, which comprise Stoneware and Cast Iron Sewers, Brick, Concrete and Cast Iron Manholes, Cast Iron Rising Main, Underground Pumping Station, Pumping Plant, etc., and other incidental works.

A copy of the Specification may be seen and Form of Tender and Bills of Quantities may be obtained on application, in writing, to Major T. J. MOSS-FLOWER, Chartered Civil Engineer, 28, Victoria Street, Westminster, S.W., and Carlton Chambers, Bristol, at his Bristol Office, on and after the 24th February, 1925, on deposit of a £5 Bank of England Note, which will be refunded provided a *bona fide* Tender be received and is not withdrawn before the sealing by the Council of one of the Tenders, and provided also that all documents supplied be returned to the Engineer. On production of a receipt for the deposit, persons tendering may inspect the plans at Havant on a day and at a time and place which will be communicated to them.

The Contractor carrying out the work will be required to comply with the regulations of the Unemployment Grants Committee with regard to the employment of labour during the performance of the Contract.

Sealed Tenders, endorsed "Tender for Havant Main Drainage Extension, General Contract No. 2," are to be delivered at the Council Offices, not later than Noon, on 14th March, 1925.

The lowest or any Tender will not necessarily be accepted, and the carrying out of the work is subject to the approval of the Ministry of Health and the Unemployment Grants Committee.

Dated this 17th day of February, 1925.

(By Order),
E. R. LONGCROFT,
Solicitor, and Clerk to the Council.

Council Offices,
Havant, Hants. H 347

Tenders Invited for Supply of

MACHINERY for making Concrete Pipes.—For particulars address, Z.O. 905, care DEACON'S Advertising Offices, Leadenhall Street, London, E.C. H 339

THE DERWENT VALLEY WATER BOARD.

PIPE TO FILTERS.

The Derwent Valley Water Board is prepared to receive

Tenders for the Laying of

about 10,000 yards of 48 inch STEEL PIPES, lined with concrete, and the Valves, Stream Crossings, etc., connected therewith.

The Specification and Schedule of Prices and copies of the Drawings may be obtained on application to Mr. S. B. WINSER, M.I.C.E., Engineer to the Board, at these Offices, on and after Monday, 9th March, on payment of Two Guineas, which will be returned on receipt of a *bona fide* Tender and the documents furnished by him.

Sealed Tenders, enclosed in the envelope supplied, with the documents, to be delivered not later than Nine o'clock, on MONDAY morning, the 23rd of March.

The Board will not be bound to accept the lowest or any Tender.

O. B. STEWARD,
Clerk to the Board.

Bamford, near Sheffield.
23rd February, 1925. H 357

ROYAL STATE RAILWAYS OF SIAM.

Sealed Tenders for the Supply

of BOGIES and UNDERFRAMES for Bogie Carriages B.E. 2468 will be received by the undersigned at his Office up to 14 o'clock on Monday, the 1st June, 1925, at which place and hour the Tenders will be publicly opened and read.

Blank Tender Forms, Specifications and Plans may be obtained from Messrs. C. P. SANDBERG, 40, Grosvenor Gardens, London, S.W.1, upon payments of £1 10s. per set, which sum will not be refunded.

Right is reserved to reject any or all Tenders and to accept any Tender which, in the opinion of the undersigned, is to the best interests of the Royal State Railways.

The Royal State Railway Department.
PURACHATRA,
Commissioner-General. H 328

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon, on Friday, 13th March,

Tenders for the Supply of :—

1. TYRES FOR CARRIAGES AND WAGONS.
2. AXLES FOR CARRIAGES AND WAGONS.
3. WHEELS AND AXLES FOR BRAKE VANS.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these offices on payment of 20/- each for No. 1, and 10/- each for Nos. 2 and 3 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France,
Westminster, S.W.1.
25th February, 1925. H 369

LONDON AND NORTH EASTERN RAILWAY.

The Directors are prepared to receive alternative

Tenders for the Supply and

ERECTION and SUPPLY ONLY of STEEL-WORK for the renewal of Seven Bridges on the Riverside Branch, Newcastle. The Contract comprises, amongst other items, about 161 tons of steelwork in troughs and decking, riveted up, painted, etc., as described in the Specification.

Drawings and Specifications may be seen, and Detailed Quantities and Forms of Tender obtained, on personal application, at the Office of the Engineer, North Eastern Area, York.

Sealed Tenders, marked "Tender for Seven Bridges, Riverside Branch, Newcastle," must be received by the Joint Secretaries, L. & N. E. Rly., Marylebone Station, London, N.W.1, by Nine a.m., on 16th March, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

JAMES McLAREN,
G. F. THURSTON,
Joint Secretaries.

Secretary's Office,
Marylebone Station.
24th February, 1925. H 360

APPOINTMENTS OPEN.

AUCKLAND UNIVERSITY COLLEGE, NEW ZEALAND.

The High Commissioner

FOR NEW ZEALAND has received a cabled notification from the University Authorities cancelling the request for application to be invited for the position of Lecturer in Civil Engineering, which position was advertised in the issue of this Journal for February 20th. H 266

Required, Translator with

technical knowledge of engineering, to translate from German into English. Occasional work only.—Write to INTERNATIONALES UBERSETZUNGS-INSTITUT, Munchen. H 315

Applications are Invited for

a REPRESENTATIVE in London for an Engineering Firm in the North. Must be an Engineer and have a thorough knowledge of power-house requirements and to be able to negotiate enquiries and follow up Tenders with the leading Consulting Engineers and Export Houses in London.

Applications will only be considered from fully qualified men, and should include age and experience, also salary required.—Address, H 371, Offices of ENGINEERING.

Estimating Engineer

REQUIRED, preferably with knowledge of Pneumatic Tools. State experience and salary required.—Address, H 332, Offices of ENGINEERING.

Engineer Required to

accompany Trading Expedition to the West Indies. Investment £500. Salary and Expenses.—Apply, G. R. MEWBURN, Solicitor, Craven House, Kingsway, W.C.2. H 338

Light Engineering—Required,

man of experience in organisation and maintenance of production programmes. Main lines of development already determined, energy and capacity required to carry same out.—Address, giving full particulars, salary required, H 230, Offices of ENGINEERING.

Wanted Marine Engineer,

with B.O.T. Certificate, for Motor Engines, or endorsement, for service in small motor vessel Red Sea Trade. Wages Rs. 375 plus Rs. 45 messing allowance, equivalent present rate of exchange to £28 2s. 6d. and £3 7s. 6d.—Write, stating full particulars, experience, etc., to THE HALAL-SHIPPING CO., LTD., 3-5, Tooley Street, London, S.E.1. H 340

Required, for London, a

Young and Practical ENGINEER and DRAUGHTSMAN. Neat and quick in designing. Good prospects. Send full particulars as to age, experience and salary required.—Address, H 362, Offices of ENGINEERING.

Civil Engineer Required

by the GOVERNMENT of CYPRUS for the PUBLIC WORKS DEPARTMENT for three years' temporary service. Salary £400 a year. Free passages for officer selected and, if married, for his wife and family. Candidates not over 35 years of age, should have passed the examination for the A.M.I.C.E or A.M.I.Mun.&Cy.E., or hold equivalent professional qualifications, and have a good knowledge of building work and road work, and must be good draughtsmen.—Apply at once by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting M/13385. H 364

Civil Engineers (4),

REQUIRED by the GOVERNMENT of CEYLON for three years' service as District Engineers in the Public Works Department. Salary £500 rising to £960 a year. (A commencing salary of £600 a year will be paid to selected candidates who have attained the age of 31.) Free passages. Candidates age between 25 to 35, should have passed the examination for Associate Membership of the Institution of Civil Engineers, and have had experience as a Contractor's Engineer on Public Works, or as an Engineer in charge of work carried out Departmentally. Must be competent in surveying (engineering) and levelling.—Apply, at once, in writing, giving age, qualifications and brief details of experience, and stating whether married or single, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting clearly at head of application M/13384. H 250

Civil Engineer Required

by the GOVERNMENT of the GOLD COAST for the lay-out of the Takoradi Township for a tour of not less than 12 nor more than 18 months' residential service in the first instance. Salary £480 for the first three years of service then £510, rising by annual increments of £30 to £720 a year, and thence by annual increments of £40 to £920 a year (the question will be considered of paying a higher commencing salary than £480 a year to a highly qualified Engineer). Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, age 25 to 40, must be A.M.I.C.E., or A.M.I.Mun.&Cy.E., or hold equivalent professional qualifications, must be good surveyors and have had experience in Road Construction, Town Planning and Drainage Works.—Apply at once, by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W.1, quoting M/13327. H 324

SINGAPORE, STRAITS SETTLEMENTS.

WATER DEPARTMENT.

ASSISTANT ENGINEER.

ADVERTISEMENT.

The Municipal Commissioners of Singapore require an

Assistant Water Engineer,

age 25-30, unmarried, on a four years' agreement, with possible extension. He must have a good technical education, a regular training as a Civil Engineer and have a practical knowledge of Surveying, Levelling and Estimating, and at least three years' experience in works of Water Supply. Preference will be given to an Assistant who has passed the examination of the Institution of Civil Engineers, as Assoc.M.Inst.C.E., The Testamur by examination of the Institution of Municipal and County Engineers will be an advantage.

Salary $5400 for the first, $5700 for the second, $6000 for the third, and $6300 for the fourth year, paid monthly in dollars, the currency of the Colony, the value of the dollar being two shillings and fourpence sterling. The pay of the appointment for the first year at this rate would be £686. Such local transport allowance as may from time to time be sanctioned by the Commissioners, will be paid. Free passage will be provided, with half-pay during the voyage out. The selected candidate must pass a medical examination.

Applications, stating whether married or single, age, and place of birth, and giving details of education, training and experience, particularly in Waterworks, and referring to all the above requirements in detail, accompanied by copies (only) of testimonials, and also personal references, must be lodged with Messrs. PRINCE & WILLIAMS, M.M.Inst.C.E., 180, Hope Street, Glasgow, Agents for the Commissioners (who will give further particulars if requested), not later than Tuesday, 10th March, 1925. H 354

THE CROSS OIL-CRACKING PLANT.

THE development of the petrol industry affords a particularly interesting example of the working of the law of supply and demand. In the early days of the petroleum industry, the most valuable constituent commercially was the kerosene which was employed as an illuminant. The heavier oils were useful as lubricants, but the lighter constituents, for which but few industrial applications then existed, were produced in larger quantities than were actually required, and had, therefore, to be marketed at low prices if they could be disposed of at all. The situation, however, was profoundly modified by the introduction of the light internal-combustion engine and its application to the propulsion of road vehicles. The subsequent development of this form of locomotion throughout the whole of the civilised world, led to an enormous demand for the lighter petroleum constituent known as gasoline in the United States and generally referred to as petrol in this country, since this particular constituent proved to be the most generally satisfactory fuel for motor vehicles. This fact, in conjunction with the introduction of improved lighting methods resulting in the partial supersession of kerosene as an illuminant, tended to place the latter in much the same position as had previously been occupied by the more volatile constituents, and the effect was greatly enhanced by the more recent development of aviation, for which petrol must be regarded as the only fuel at present available.

Both forms of locomotion were employed to such an extent during the European war that an unprecedented demand for petrol was created, giving rise to some anxiety as to the adequacy of supplies, particularly as these had to be maintained by overseas transport in face of the enemy's submarine campaign. Even for some period after the war the relationship between supply and demand was such that prices five or six times those ruling in pre-war days were obtained for petrol in this country, and although conditions have since become more normal, the large and ever-increasing demand for petrol is the main factor in the production of petroleum.

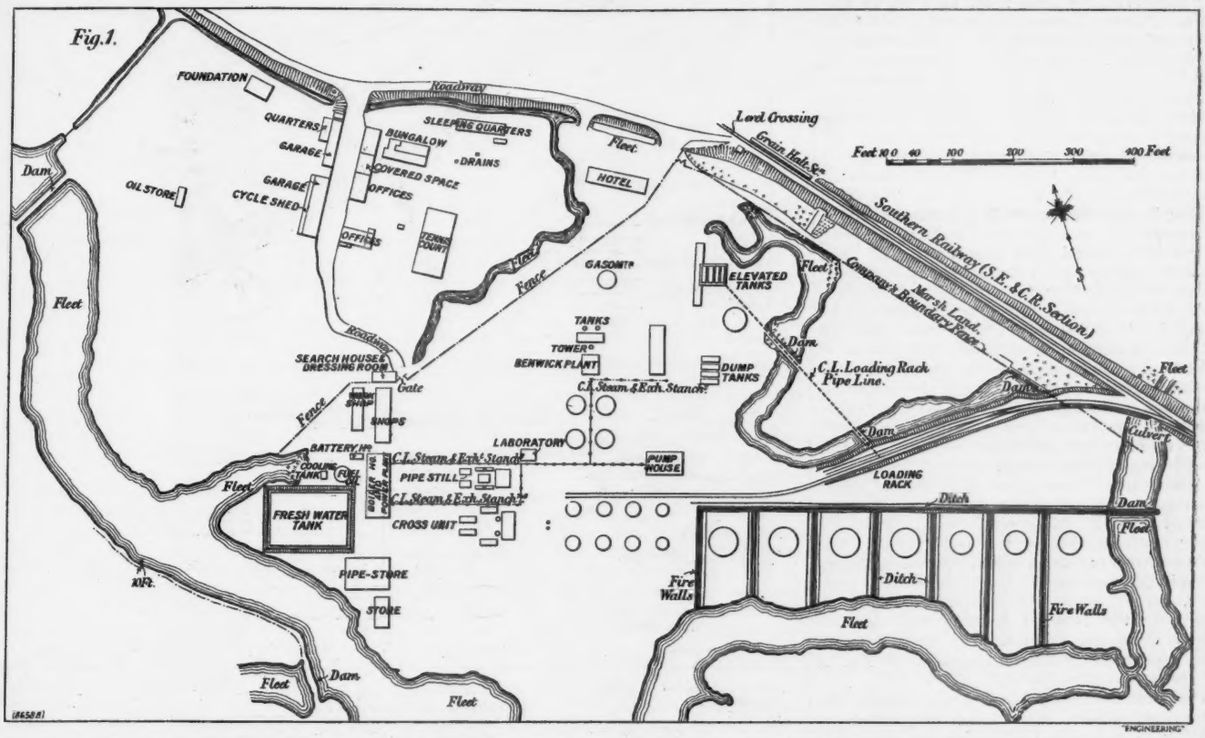
The proportion of petrol contained in crude petroleum as delivered from the wells varies in different parts of the world, that from American oil fields amounting to about 27 per cent. The other main constituents and their proportions may be taken roughly as gas and fuel oil, 46 per cent., kerosene, 10 per cent., and lubricant, 4 per cent. the remainder being accounted for by wax and asphalte. The simplest method, and that most generally employed, for separating the constituents of crude petroleum is that of fractional distillation, the various fractions coming over at temperatures corresponding to their boiling points as the temperature of the oil in the still is gradually raised. In this process of distillation, the mixed constituents of the crude oil are not changed chemically to any appreciable extent, but merely separated physically, the proportions of each in the distillate being substantially the same as were present in the crude oil. It is possible, however, by the application of heat and pressure under suitably controlled conditions, to bring about an actual chemical change in some of the heavier oils, whereby the complex hydro-carbon molecules are split up and the more valuable volatile constituents are formed. For example, petrol can be produced in this way from kerosene, gas oil, fuel oil and low-grade crudes.

Such processes are known as "cracking" processes, and the first plant to be used was developed by Dewar and Redwood some forty years ago. The Standard Oil Company subsequently developed a somewhat similar process, known as the Burton process, and used it on a large scale as early as 1913. The cracked spirit was blended with ordinary distilled spirit. The Burton process is of the liquid-vapour phase type, in which cracking occurs simultaneously with distillation; it has been remarkably successful and is largely employed. Vapour-phase cracking in which vapours of heavy oils are heated to a high temperature at pressures but little above that of the atmosphere has not, in general, proved satisfactory in practice. In a third class of cracking process the heavier oils are heated to a high temperature under sufficient pressure to keep them substantially in the liquid phase. Pressures ranging from, say, 500 lb. to 800 lb. per square inch are required, but the operations can be carried out in comparatively small vessels, and the process has the advantage that no heat is absorbed in vaporising the oil.

The Cross process, with which we are now concerned, is of the last-mentioned type and was developed on a laboratory scale by Doctors R. and W. Cross, of Kansas City, in 1912. The completion of designs for commercial-scale plant occupied a further period of four years, and between 1916 and 1921 two plants were constructed and operated successfully. The process was then made generally available for the petroleum industry, and has since been developed on a large scale. At the present time about 70 Cross cracking plants are in operation in the United States alone, their aggregate capacity, amounting to some 300,000,000 gallons of petrol per annum. The special advantages claimed for the Cross process are an exceptionally high yield of petrol, a high degree of safety owing to the absence of welded and riveted joints in the high-pressure parts, low-fuel consumption resulting from the fact that heating is carried out in the liquid phase only, and low capital and production costs on account of the relatively small size of the plant for a given capacity. One of these plants is now in full operation in this country, having been installed by Mr. C. F. de Ganahl, the managing director of the Medway Oil and Storage Company, Limited, at the firm's refinery in the Isle of Grain, Kent. This plant, which we propose to describe in some detail, was the first of its kind to be put to work in this country, although another is now in course of construction and further installations are contemplated. The particulars which we are able to give, by the courtesy of Mr. de Ganahl, and of Colonel the Master of Sempill, who has been assisting in this country the M. W. Kellogg Company of New York, who are responsible for the technical and commercial development of the Cross process, should, therefore, be of considerable interest.

The Isle of Grain, we may remind our readers, is situated at the mouth of the Thames, at the point where the latter is joined by the Medway, Grain being on the western side of the Medway, while Sheerness is on the eastern side. The plant of the Medway Oil and Storage Company, Limited, a general plan of which is given in Fig. 1, is located between the northern bank of the Medway and a branch line of the Southern Railway running from Gravesend to Port Victoria, so that ample facilities exist for the transport of raw materials and finished products by rail and sea. Two dolphins have been constructed, and suitable moorings provided in the Medway for the accommodation of deep sea.

Fig. 1.


FOUNDATION
QUARTERS
GARAGE
GARAGE
CYCLE SHED
OIL STORE
Dam
Roadway
SLEEPING QUARTERS
BUNGALOW
DRAINS
COVERED SPACE
OFFICES
OFFICES
TENNIS COURT
HOTEL
Fleet
Fence
Lord Crossing
Grain Halt Sta.
Feet 100 40 100 200 300 400 Feet
Southern Railway (S.E. & C.R. Section)
Gravesend Boundary Fence
Marsh Land
GASOMETER
ELEVATED TANKS
TANKS
TOWER
BERWICK PLANT
DUMP TANKS
C.I. Loading Rack Pipe Line.
C.I. Steam & Exh. Stands
SEARCH HOUSE & DRESSING ROOM
Gate
SHOPS
LABORATORY
BATTERY H.P.
COOLING TANK
FUEL
C.I. Steam & Exh. Stands
PIPE STILL
C.I. Steam & Exh. Stands
PUMP HOUSE
LOADING RACK
FRESH WATER TANK
CROSS UNIT
Ditch
Culvert
Fire Walls
Ditch
Fire Walls
PIPE-STORE
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tankers and a pier has been constructed to carry the necessary pipe lines to enable tankers to be discharged or loaded at all states of the tide. Fig. 2 shows the arrangement of the pier and dolphins, while details of the moorings are given in Fig. 3. As shown in Fig. 2, four storage tanks, each 82 ft. 6 in. in diameter by 30 ft. deep, are provided near the pier, and several others have recently been added, although not shown in the illustration. For filling and emptying these tanks three steam pumps of the horizontal direct-acting type have been installed in a pump-house measuring 50 ft. long by 26 ft. 2 in. wide. An interior view of this pump-house is reproduced in Fig. 7 on Plate XVI, accompanying this issue; steam is supplied from a separate boiler-house, the position of which is indicated in the plan, Fig. 2.

The pier is located at a distance of about three-quarters of a mile from the main plant and is connected to the latter by a pipe line, consisting of four pipes ranging from 2 in. to 6 in. in diameter. Further storage accommodation for oil and petrol is provided at the plant, as indicated in the plan, Fig. 1. Seven tanks, shown in the bottom right-hand corner of the latter, are illustrated in Fig. 5 on Plate XV. Of these the four on the left, painted white, are used for petrol, two of the remainder being used for partially-cracked oil, known as recharging stock, while the other is used for storing kerosene. Four other tanks for petrol are illustrated in Fig. 6 on the same plate. The small building in the foreground of this illustration, on the right-hand side, houses the Benwick absorption plant for recovering petrol from vapour given off from the tanks and from gases produced in other parts of the plant. Altogether, the storage tank capacity of the whole plant is sufficient for 2,500,000 gallons of petrol, 11,000,000 gallons of kerosene, 900,000 gallons of recharging stock, and 80,000 gallons of fuel oil. A second pumping house is provided in the works for handling the contents of the tanks, the equipment including eight Hayward-Tyler pumps, with an aggregate capacity of 41,000 gallons per hour. Fig. 8 on Plate XVI illustrates the interior of this pump house. Steam is supplied from a boiler house containing three Babcock and Wilcox units, which also supply a 30-kw. Belliss generating set and a Sentinel steam-driven air compressor, located in a power station adjoining the boiler house. The main source of electric power is, however, a 75-kw., 460-volt, Metropolitan-Vickers direct-current generator, driven by a 110–120-h.p., horizontal oil engine by the Imperial Keighley Gas and Oil Engine Company, Limited. The other items of plant equipment, which are indicated in Fig. 1, call for no special comment.

The chief items of interest are, of course, the Cross cracking units, two of which, each capable of treating 1,000 barrels (36,000 Imperial gallons) a day, have been installed, and we understand four additional units of the same capacity are about to be put down. The plant, which can be used for cracking gas oil, fuel oil or kerosene, has been employed, so far, mainly with the last-mentioned oil, although arrangements have now been made for cracking fuel oil if desired. The general arrangement of the two cracking units is illustrated in Figs. 9 and 10, on Plate XVI, but, before describing the various parts in detail, it may be useful to explain the process more fully with the aid of the diagram reproduced in Fig. 4 annexed.

It will be seen that the plant consists of five main parts, a tubular heater, a cylindrical steel reaction chamber with coned ends, a vaporiser, a dephlegmating tower and a gas separator. In using the plant for cracking kerosene, a mixture of equal parts of the latter and of the partially-cracked recharging stock, the source of which will be explained later, is pumped through the tubular heater into the reaction chamber. This part of the system, shown in solid black in Fig. 4, is operated at a pressure of 700 lb. per square inch, but in the remainder of the system only moderate or low pressures are employed. The oil, which is pumped through the heater, enters the reaction chamber at a temperature of about 900 deg. F., passing slowly through it in the course of about half an hour and leaving through a control valve at the opposite end. The reaction chamber is carefully lagged to reduce heat losses and the temperature is

CROSS OIL-CRACKING PLANT ON THE MEDWAY.

Fig. 2.

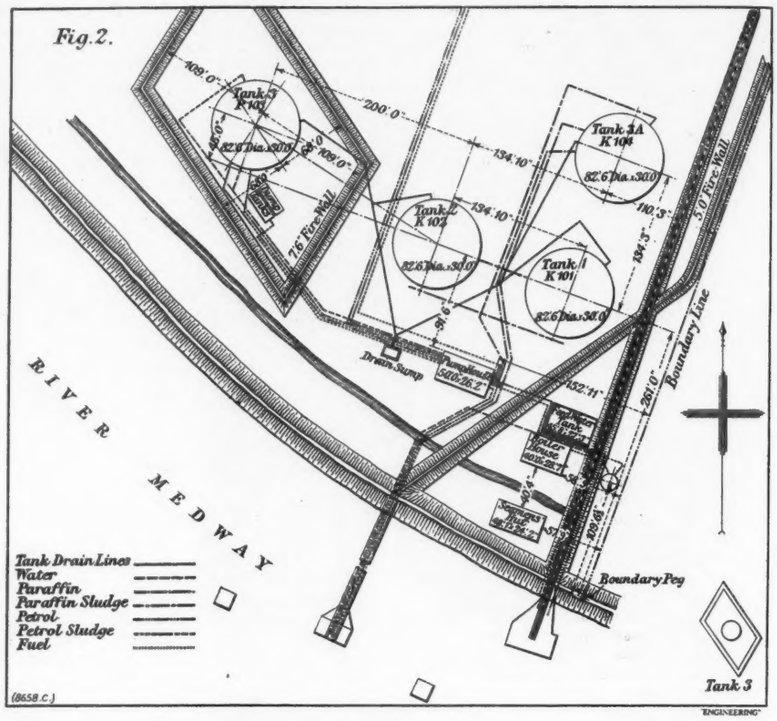
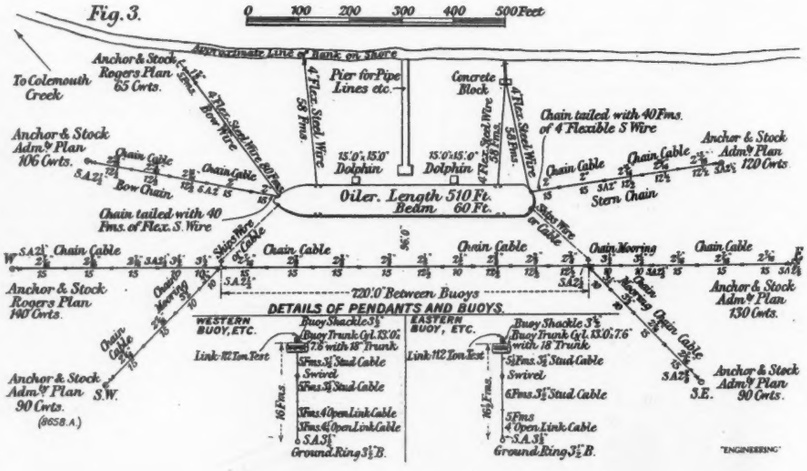


Fig. 3.


0 100 200 300 400 500 Feet
Approximate Line of Bank on Shore
To Colemouth Creek
Pier for Pipe Lines etc.
Concrete Block
Oiler. Length 510 Ft. Beam 60 Ft.
720'0" Between Buoys
DETAILS OF PENDANTS AND BUOYS.
WESTERN BUOY, ETC.
EASTERN BUOY, ETC.
Anchor & Stock Rogers Plan 65 Crts.
Anchor & Stock Adm.ty Plan 106 Crts.
Anchor & Stock Rogers Plan 140 Crts.
Anchor & Stock Adm.ty Plan 90 Crts.
Anchor & Stock Adm.ty Plan 120 Crts.
Anchor & Stock Adm.ty Plan 130 Crts.
Chain tailed with 40 Fms. of Flex. S. Wire
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Bow Chain
Stern Chain
Chain Moorings
Ground Ring 3½ B.
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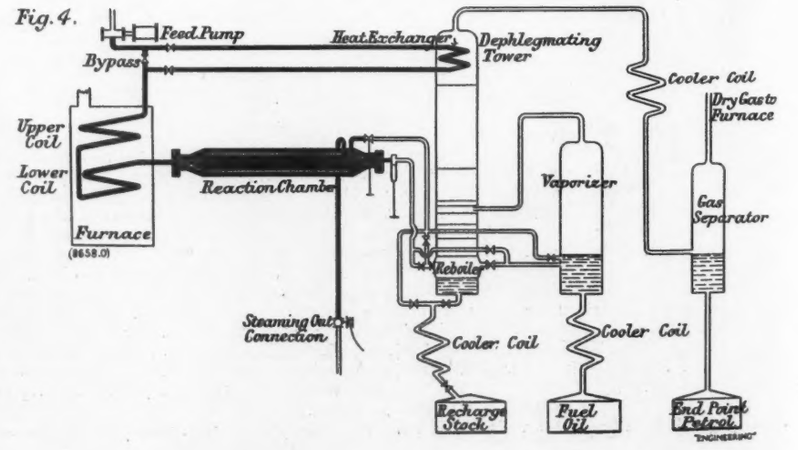
Fig. 4.



well maintained, being about 750 deg. F. at the outlet end. The cracking effected by the combined effects of the heat and pressure in the reaction chamber changes the kerosene into a liquid similar in characteristics to the crude oil from the wells, and the various fractions of this synthetic crude oil are separated by a process of fractional distillation without the addition of further heat.

The mixture of cracked oil and vapour which leaves the reaction chamber through the control valve passes through a tubular re-boiler in the lower part of the dephlegmating tower giving up some of its heat in this way to the liquid collected there, the liquid being thereby partly re-evaporated. After passing through the re-boiler, the mixed liquid and vapour passes into the vaporiser, which is a simple vertical cylindrical vessel. In this vessel, in which the pressure is about 20 lb. per square inch, while the temperature is about 675 deg. F., the liquid and vapour are separated. The former, which is a heavy oil and is useful for boiler firing and similar applications, collects in the bottom of the vaporiser, whence it is run off through a water-cooled coil to a separate tank. About 15 per cent. of the kerosene supplied to the plant is accounted for in this way. The vapour is led from the top of the vaporiser into the lower part of the dephlegmating tower in which it passes up through a series of superimposed trays on which the less-volatile fractions are condensed. These trickle down to the bottom of the tower where they collect around the re-boiler, and the heat supplied from this keeps the temperature of the liquid in the bottom of the tower at about 665 deg. F., which is sufficient to ensure the evaporation of any petrol at the pressure of 20 lb. per square inch maintained in the tower. The remaining liquid, which is drawn off through a cooling coil and run into a storage tank, constitutes the re-charging stock already referred to.

In the top of the dephlegmating tower the vapour comes into contact with a coil of piping through which the oil flows on its way to the heater. The oil is therefore heated by the condensation of the vapour and this heat is returned to the system. By regulating the flow of oil through the coil, by means of a by-pass valve, the temperature of the upper part of the tower can be adjusted if required, but, in general, temperature control is effected by a water-cooled coil not shown in the diagram. Temperature control at this point, it may be mentioned, is of considerable importance, since it provides a means for regulating the final boiling point of the petrol produced by the process. This, of course, follows from the fact that only those constituents which remain in the form of vapour at the temperature of the upper part of the tower, or at lower temperatures, can pass out through the pipe connecting the tower with the gas separator.

As indicated in the diagram, this pipe includes a water-cooled coil in which the vapours are condensed and the condensed vapour is subsequently separated from the non-condensable gases in the vessel shown on the extreme right of Fig. 4; both the temperature and pressure in this vessel are practically atmospheric. The gas, it should be explained, is used in the burners of the heating furnace and the quantity produced, which depends to some extent upon the character of the oil being cracked, is generally sufficient to supply the whole of the heat required for the process when working normally. If necessary, it can be supplemented by burning the fuel oil, and in any case the latter must be used for the first few hours when starting a run. The condensed vapour, which constitutes the final product of the cracking plant, is run off from the separator into storage tanks and, after purification in an acid plant of the usual type, is marketed under the name of "Power petrol." We shall deal more fully with its characteristics later, but we may now mention that the quantity produced amounts to about 75 per cent. of the kerosene supplied to the plant. As already stated some 15 per cent. of the kerosene supplied is returned as fuel oil and the remainder is accounted for by losses, gas and coke. Most of the latter collects on the walls of the reaction chamber. The coke must be removed after a run of about 15 days with kerosene, and it can be used as fuel although the quantity produced in hardly sufficient to justify it being marketed. A steam connection, indicated in Fig. 4, is used for steaming out the reaction chamber before the work of cleaning is commenced.

From the elevation and plan reproduced in Figs. 9 and 10 on Plate XVI, the arrangement of the various components of the two units can be followed and their functions will be understood from the above general description. We shall describe their design and construction more fully in a later article, but it will be convenient now to refer to the method of controlling the working of the plant. This is carried out from the house shown at the right-hand end of the plant as drawn in Figs. 9 and 10; views showing the interior of the house are reproduced in Figs. 11 to 14 on Plate XVII. The kerosene and recharging stock is drawn from the storage tanks by steam-driven duplex pumps, and delivered by them to the suction connections of high-pressure direct-acting steam pumps, which, in turn, deliver the oil to the heater tubes at a pressure of 700 lb. per square inch. There are two low-pressure and two high-pressure pumps to each unit, and they are located in the control room on each side of a central instrument board. Fig. 12 shows this board and one set of pumps, the other set being illustrated in Fig. 11. As previously stated, part of the oil supplied to the heater is passed through a coil on the upper part of the dephlegmating tower, and the valves controlling the proportion by-passed are located in the control house so that the temperature can be regulated with the aid of an electrical thermometer mounted on the instrument board; the latter is shown on a larger scale in Fig. 13.

The main control of the working of the plant, however, is effected by means of the valve at the outlet of the reaction chamber, in conjunction with the regulation of the speed of the pumps. By means of the latter the rate of flow of the oil through the heater, and consequently the temperature attained, can be varied, while the pressure in the heater and in the reaction chamber can be lowered or raised by opening the outlet valve more or less. The handwheels controlling the opening of the valves on one of the reaction chambers can be seen on the left of the instrument board in Fig. 12, the spindles passing up to the valves through the roof of the house. The effects of the adjustments made can be seen at once by the instruments which are mounted on the board in two groups, one for each unit. Of the instruments shown in Fig. 13, the three small gauges at the top give the pressures at the inlets and outlets of the pumps; the larger gauge in the centre shows the steam pressure, while two others on the right record and indicate the pressure in the reaction chamber. Below these gauges, indicating and recording pyrometers give the temperature at the top of the dephlegmating tower, of the oil entering the reaction chamber and of the heater furnace, while the small gauges at the bottom of the board indicate the pressures in the cooling or condensing coils. On the wall opposite the instrument board are mounted a number of mercury columns indicating the contents of the tanks connected with the working of the plant, and a meter indicating and recording the quantity of gas leaving the separators. These instruments are shown in Fig. 14, on the right of which will be seen an indicating pyrometer with a multiple switch enabling the temperature at all important points in the plant to be determined at will.

(To be continued.)

TECHNICAL TRAINING IN THE ARMY.—It is not generally realised that some thousand boys are at the present time receiving a training extending over a period of three years in engineering trades, such as those of armourer, artificer, electrician, fitter, &c., at the Military Schools at Chepstow, Maresfield, and other establishments throughout the country. Attention has been called to the fact by the announcement that there are vacancies occurring for 200 boys, who will be selected by competitive examinations to be held on March 3, at various centres in the United Kingdom. Candidates, who must be over 14, but under 15 years and 4 months on May 1, 1925, will be examined in English, arithmetic, and general knowledge. Application forms and further information relating to the scheme may be obtained from all Army Recruiting Officers.

SAFEGUARDING INDUSTRIES.

THE Government's scheme for safeguarding British industry, as indicated in the regulations recently issued by the Board of Trade, has given rise to a good deal of disappointment amongst those who looked forward to substantial improvement in the means of defence against unfair foreign competition. In many circles it was expected that a Bill would be introduced on somewhat broader and simpler lines than those of the Safeguarding Act of 1921, so that if a good case for the imposition of a duty were made out, an order would be made forthwith by the Board of Trade and would become operative subject to its confirmation by the House of Commons, which followed more or less automatically. The new procedure affords the applicant who has run the gauntlet of a preliminary enquiry by the Board of Trade and a searching enquiry by a Committee no assurance, however, that he will get his order as the result of this ordeal.

The proposals, if any are made by the committee, for the imposition of duties will be embodied in a Finance Bill, and will be open to attack on the floor of the House just in the same way as any novel duties proposed by the Chancellor of the Exchequer. In other words, the applicant has to prove his case three times over. He has to satisfy the Board of Trade, the *ad hoc* committee and the House of Commons. Strong and clear indeed must be the case which can win its way triumphantly through such obstacles. But, apart from the procedure, there are some interesting points to be noted in comparing the conditions which the applicant has to fulfil as contrasted with those which he had to satisfy under the provisions of Part II of the Safeguarding of Industries Act, 1921.

Broadly speaking, the new regulations proceed on much the same lines as the old, though perhaps affording here and there a little more scope and latitude. Any British manufacturer who desires to get a duty imposed upon imported foreign goods on the ground of unfair foreign competition has, in the first instance, to satisfy the Board of Trade that he has a *prima facie* case. If he succeeds in satisfying the Board of Trade as to this, his application is then referred to an *ad hoc* committee appointed by the President of the Board of Trade, which fully investigates the facts and reports whether the applicant has established a claim to a duty.

This is substantially the same procedure as that described in Part II of the old Act. The conditions, however, which the applicant has to satisfy in order to make out a *prima facie* case, are different. Under the old regulations, the applicant was faced with the extremely difficult task of making out a case based on a concatenation of causes. Beginning at the final link of the chain, he had to show that there was unemployment in the trade concerned, and that this was due to foreign competition. He had next to show that this was due to foreign goods being sold in this country at prices below the prices at which similar goods could be profitably made in the United Kingdom. He had finally to show that this disparity in prices was due to depreciated currency. It was therefore essential to the success of his case to prove that depreciated currency was the real root of the evil, otherwise the application failed. It is not surprising that few applicants essayed the task, and fewer still survived the ordeal of proving such a case. As the result of 14 applications made under Part II for an order on these grounds, only two orders were eventually made.

It is noticeable that the stringent and extremely limited conditions prescribed under the old regulations have been materially relaxed and widened under the new, while some salutary conditions have been added. The Board of Trade rightly require to be satisfied in the first place that the industry concerned is one of substantial importance, providing, or capable of providing, a considerable volume of employment. The second requirement of the Board, namely, that the competition of foreign imports in the industry must be shown to be "exceptional," might with advantage have been more explicit. One naturally asks "exceptional in reference to what?" Is the present state of the industry to be compared with its state in

preceding years, or is the amount of competition in one industry to be contrasted with the amount in a kindred industry? Or is it to be considered that if the proportion of imported goods is 25 per cent. of the British manufacture of the same description of goods, such competition is not exceptional, but if it were 75 per cent., it would be exceptional? These are questions upon which some further information would be acceptable.

The third point, upon which the applicant has to satisfy the Board of Trade that he has got a *prima facie* case, is that the competition from which his trade is suffering is unfair. Three kinds of unfair competition are detailed, viz.:—(1) competition arising from depreciation of currency operating so as to create an export bounty; (2) subsidies, bounties or other artificial advantages; (3) inferior conditions of employment.

This is a substantial widening of the grounds open to the applicant under the former regulations. Depreciation of currency is no longer a *sine qua non* as the ground for a successful application. At the same time it must be recognised that the task of showing that the cheap price at which foreign goods come into this country is due to "inferior conditions of employment" will be by no means an easy one. And again, it is to be observed that the language used in this regulation is not clear. What are inferior conditions of employment? Is a man who works at piece-work rates employed under inferior conditions compared with a man doing the same work at so much per hour? Or are the conditions of employment inferior in the case of a man who works nine hours a day as compared with a man who works seven hours a day? There are obviously two points of view as to whether the conditions of employment are inferior or superior. The Trades Union's view might easily be exactly the opposite of the employer's view.

Assuming that the applicant makes out a *prima facie* case, the matter is then referred to a Committee which need not necessarily, as under the former regulations, consist of five members, this number being in the new regulations merely the maximum. The various matters into which the Committee is to inquire are numerous, but it is noteworthy that the Committee's power to recommend that a duty should be imposed is not conditional upon its finding affirmatively or otherwise upon all the matters upon which it has to report. For example, one of the matters into which it has to inquire is whether the foreign goods are being sold or offered for sale in the United Kingdon at prices which are below the prices at which similar goods can be profitably manufactured in the United Kingdom. Under the provisions of Part II of the Act of 1921, the Board of Trade could make no order unless the Committee had found this as a fact. Apparently, this is no longer necessary. Cases may well exist or might arise in which the foreign goods are imported into and consumed in the United Kingdom in abnormal quantities and in which foreign competition is exceedingly severe and detrimental to British trade notwithstanding the fact that the price at which the foreign article is sold in this country is not below the price at which a similar article can be profitably manufactured by British labour. In such a case the Committee might well see fit, other conditions being satisfied, to report that the applicant has made out a good case for the imposition of a duty.

In another important respect the new regulations give a greater latitude than the old. Under the provisions of the Act of 1921, the only rate of duty which could be imposed was a duty equal to one-third of the value of the goods. The absurdity of this limitation was exemplified in the gas mantle manufacturers' application where the difference between the German cost of manufacture and the British cost, was so great that a duty of 33⅓ could obviously afford no effectual protection whatever to the British manufacturer.

The new regulations leave it to the Committee to report what in their opinion the rate of duty should be. It is perhaps a pity that the Committee is not also asked to recommend the period for which the duty should be imposed. The period, so the Board of Trade announcement states, is to be a "limited period," the limits of which will be prescribed in the Finance Bill. Doubtless, care will be taken to ensure that the prescribed period is a short one, but capable of extension by renewal of the order from time to time, provided that it is serving the purpose for which the duty was imposed namely, the stimulation of British trade and the diminution of unemployment.

There is one other matter with which these regulations do not deal and which deserves consideration. Some provision is required for cancelling or revoking orders made under these regulations when the conditions which justified the imposition of the duty have ceased to exist.

The maintenance of a duty for the safeguarding of an industry which for one reason or another has ceased to deserve or require safeguarding might become a serious abuse, and some means should be provided, besides the initiative of the Board of Trade, to guard against it.

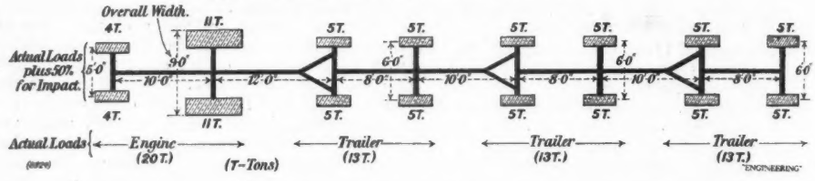
BRIDGE RECONSTRUCTION WORK OF THE MINISTRY OF TRANSPORT. No. I.

IT is of course a commonplace that the development of our railway system led to the disappearance of traffic from our roads. The stage coach was commonly followed, in dry weather, by "a trail of dust as long as the Mall," a concomitant of the "good old coaching days" ignored by the laudators of past times, and unrealised by the generation which witnessed the advent of the motor car, and the consequent return of traffic to the roads. The dust nuisance then occasioned, has, however, presented the least difficult of the problems which have had to be faced by our road engineers. The motor car soon drew attention to the fact that a large proportion of our highways were without proper foundations, and this weakness has been accentuated by the extremely rapid growth of industrial road traffic. The motor lorry is of considerable weight and attains speeds which would have been considered very fast even for light traffic 30 years ago. This combination of speed and weight is exceedingly destructive to roads with inadequate foundations or indifferently maintained. To-day the road engineer is confronted with still other difficulties due to the fact that weights, which are refused by the railway companies as excessive or too cumbrous, are being transported by road.

Obviously, the availability of a highway for such traffic is fixed by the strength of the weakest bridge on the line of route, or by the crookedness and narrowness of streets in old-world towns and villages. In our industrial areas the road authorities have done, and are doing, very much to suit the roads for the traffic offering. Many of our great trunk routes however, pass for long distances through sparsely inhabited areas, where there has been no sufficient inducement for the local authorities to carry out improvements, required mainly for the benefit of through traffic. The Ministry of Transport are now, however, making special arrangements for the elimination of obstructions thus originating. Their object is to render the great trunk roads from end to end fit for all the traffic using them. In many cases this will involve the construction of by-pass roads round old-world towns, where the straightening and widening of tortuous streets, or the easing of bridge approaches would not only be costly, but is also undesirable on historical and aesthetic grounds. These latter considerations have also influenced the Ministry in deciding them, in certain instances, to build a new bridge rather than to strengthen and reconstruct an old one. Each case has of course to be considered on its merits, and it would often be unjust and unreasonable to condemn a populous and growing city to the permanent retention of an awkward and narrow bridge interpolated in a main thoroughfare. Moreover, it by no means follows that every old and inadequate structure has necessarily any considerable artistic and historical value.

If our trunk roads are to take heavy traffic from end to end, it is, of course, essential that all bridges from the least to the greatest shall be capable of carrying the heaviest load admitted on the roads. Hitherto standards have varied widely and it should be said that it is not always the oldest bridges which are the weakest. Through bridges of relatively recent construction with shallow trough floors are often much weaker than many of their predecessors. In this connection it may be added that local surveyors have frequently unnecessarily restricted the loads admitted to the bridges under their control. As a notable instance of this we may cite the old bridge of several arches, on the road to the camp which was formed at Bovington in Devonshire during the war. At each approach to this there was a notice asserting that the bridge was suitable for light traffic only. Yet this same bridge was traversed hundreds of times by tanks weighing 25 to 30 tons each, and suffered no injury. A similar condition of affairs has been recorded on several occasions since the war, when local surveyors have refused to allow over certain bridges, loads which actual experience have proved to be perfectly safe.

Fig. 1. STANDARD LOAD FOR HIGHWAY BRIDGES.



It would be well if an appeal from such unreasonable rulings were possible to the Ministry of Transport. A local surveyor may, of course, be a very competent man for his job, even if he is not an expert on the strength of structures. In the latter case it is quite natural that he should play for safety, but both the would-be road user and the surveyor would undoubtedly be prepared to admit in disputed cases the ruling of the Ministry as conclusive. Its technical head, Sir Henry Maybury, was not only one of the most successful of the road engineers, who had to provide remedies for the troubles arising from motor traction, but he had also very special experience when in charge of the highways and bridges behind our lines in France.

Until quite recently there was no generally accepted standard of loading for highway bridges. To a limited extent some degree of uniformity was imposed by the various Acts relating to road locomotives. Under the Act of 1861 the maximum weight of a road engine was fixed at 12 tons, and its width at 7 ft. The act provided, however, that these limits might be exceeded with the consent of the local authority, and this permission was fairly freely accorded either tacitly or on application, in certain industrial areas. By the same Act the load on unsprung trailers was limited to 2 tons per axle.

An amending act was passed in 1878 by which the weight was increased to 14 tons and the width to 9 ft. Another amending Act passed in 1898, provided a penalty for the carrying of excessive weights in wagons. It, however, enacted that a waggon carrying an indivisible article of greater weight than 14 tons might be allowed without special permission, provided that the tyre widths should not be less than 8 inches. Even if the wagon owner complied with this recommendation he was not freed from responsibility for any special damage done. By this Act the number of trailers was limited to three. Indirectly these various acts did provide guidance for the designers of highway bridges, but the first regular specification

THE RECONSTRUCTION OF THE WATERLOO BRIDGE, BETTWS-Y-COED.

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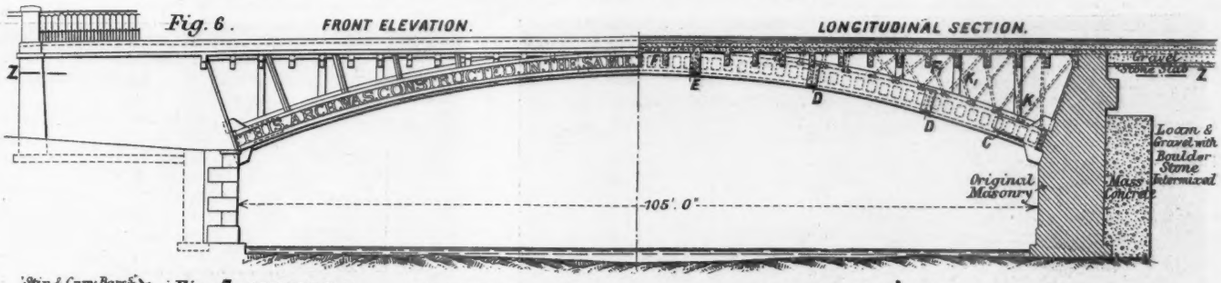
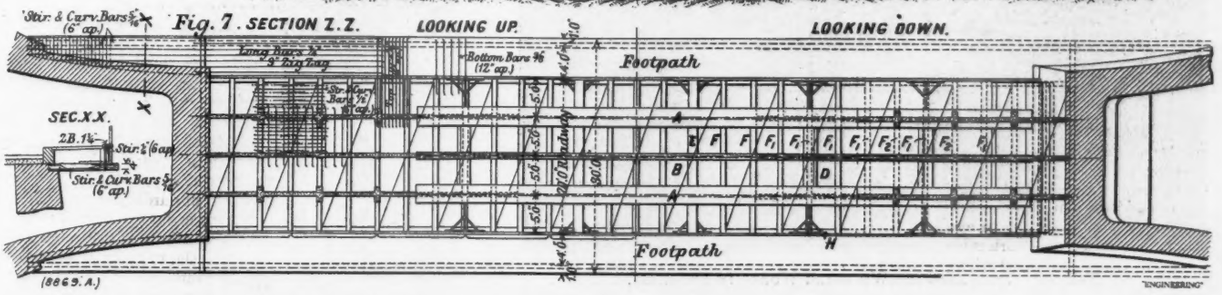
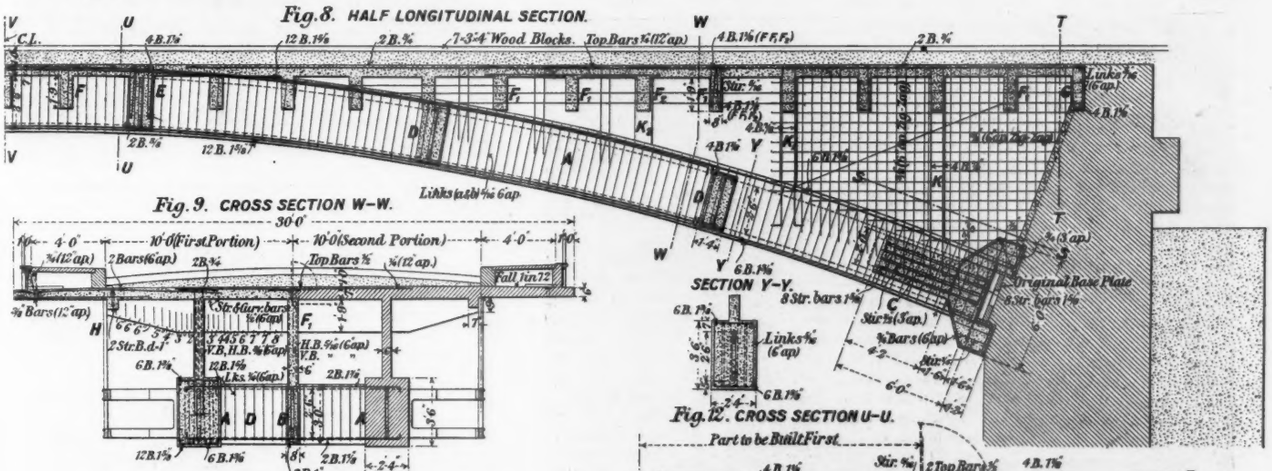
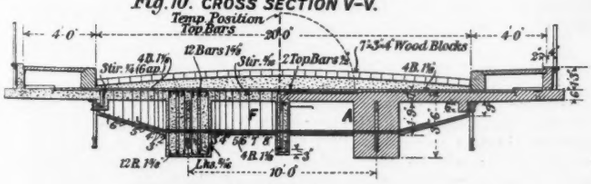
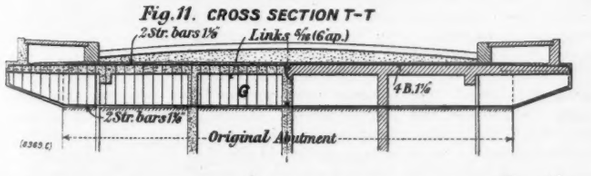
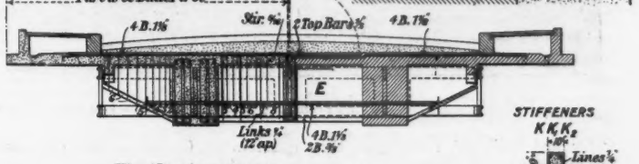


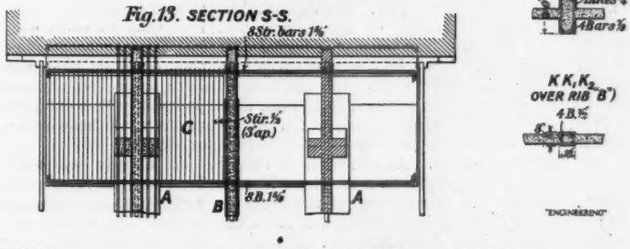






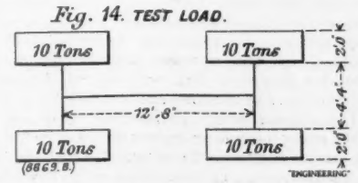






of standard loads was drawn up by the Ministry of Health. This standard load was one 12-ton road roller so placed as to cause the maximum stress in the various parts of the structure. The load in question was to be considered a live load with an allowance of 50 per cent. for impact.

When the Ministry of Transport came into being it adopted a standard load consisting of a 16-ton tractor with two-thirds of its weight on the rear wheels and three 8-ton trailers with weight equally distributed between both axles, an impact factor of 50 per cent. applying to the whole. Each



train was considered as occupying a section of the roadway 10 ft. wide, and as many trains as its width would permit had to be allowed for side by side on the carriageway in designing a road bridge. The current standard load of the Ministry embodies a similar condition and has to a large extent been responsible for the practical elimination, for moderate spans, of the type of bridge with two main girders and a floor supported by cross girders. This type both in steel and concrete has generally been replaced by one in which main longitudinal girders spaced at about 5-ft. centres are employed.

The Registration and Licensing Regulations, 1921, Part VI, increased the maximum weight of an unsprung locomotive to 20 tons inclusive of

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Fig. 15. View showing Widening Works in Progress.

Fig. 16. View of Underside of Arches showing Timbering.

Fig. 17. Method of Supporting Arches during Reconstruction.

water and fuel, not more than three-quarters of this weight to be on the rear axle. Shortly after this, the current standard loading of the Ministry was decided on. This standard loading is represented in Fig. 1, page 250. It will be seen that the weight of the tractor is increased to 20 tons, and that of the trailers, still three in number, to 13 tons, thus approximating closely, when the tare of the trailers is taken into account, to the legal limits specified in the 1921 Regulations. An allowance of 50 per cent. for impact is superposed on the above loading and the number and arrangement of the trains to be allowed for in designing a bridge are as in the original standard load of the Ministry.

Since practically all the highway bridge construction in the country is receiving financial aid from the Ministry this standard loading governs the proportions of all new highway bridges. It is considerably heavier than that prescribed in other countries, but past experience has demonstrated that as traffic develops weights tend to increase. In this country our early railway engineers constructed many bridges with what has proved to be a large margin of safety, and these bridges have proved perfectly capable of sustaining loads far in excess of those originally contemplated. Owing to this circumstance, relatively much less of very expensive reconstruction has been necessary here, than in some countries, where bridges were less liberally proportioned *ab initio*. It would be poor economy to design highway bridges merely for present requirements, with the consequent probability that extensive strengthening or replacements would have to be undertaken in another 20 or 30 years.

As already indicated above, the Ministry of Transport have a high regard to historic and æsthetic considerations. Hence when it has been necessary to reconstruct existing bridges the work has been designed to interfere as little as practicable with any artistic or archaeologic value the structure may possess. An interesting example of this is afforded by the strengthening of the famous Waterloo Bridge at Bettws-y-Coed, which we illustrate in Figs. 2 to 16 above, and on pages 251 and 262.

The original bridge at Bettws-y-Coed was one of the many interesting bridges designed by Telford, the famous engineer, who became the first President of the Institution of Civil Engineers. It was constructed in 1815, a fact which is recorded in the casting of the outer arched ribs by the words running the whole length of the ribs as shown in Fig. 2, page 262, "This arch was constructed in the same year the Battle of Waterloo was fought." The bridge consisted of three inner cast-iron ribs and two outer cast-iron ribs carrying the parapets, having a clear span between the abutments of 105 ft. and a rise of 9 ft. 6 in. The arrangement can be readily followed in Figs. 6 and 7, page 251, although these represent the present condition of the structure as strengthened with ferro-concrete. These arched ribs were connected to each other by cast-iron stiffeners and the decking of cast-iron plates was carried above the ribs by means of diagonal cast-iron struts. The arches took bearing upon cast-iron plates embedded in the face of masonry abutments. The cast-iron ribs were only 2 in. in thickness and their depth at crown was 2 ft. 6 in., the web of the arches being panelled with openings about 1 ft. wide. The width of the bridge was 20 ft., see Fig. 3, page 262.

In 1911 the County Councils of Carnarvonshire and Denbighshire became somewhat perturbed as to the sufficiency of the bridge to take modern traffic, and the matter was accordingly investigated by the Surveyor of the Carnarvonshire County Council, the late Mr. E. Evans, A.M.Inst. C.E. A strengthening was considered to be necessary and schemes were prepared for carrying this out in ferro-concrete. It was unanimously desired that the reconstruction of the bridge should not involve scrapping the old structure, but that this should be retained as far as possible and its character left unimpaired. Though decided on, the prosecution of the work was prevented by the outbreak of the war and the matter remained in abeyance for some years. In 1920 and 1922, the question again came up and was reconsidered by the new County Surveyor, the late Mr. D. R. Parry, and further plans were prepared in conjunction with Messrs. L. G. Mouchel and Partners, Limited, who were called in to design the reinforced concrete work. Their proposals were examined and approved by the Ministry of Transport, who made a grant of 4,242*l.* from the Road Fund, this figure representing half

the total cost. A contract was let in 1922, and the work was completed and tested in 1923.

The strengthening was effected by embedding the three internal cast-iron ribs in the centre of new ferro-concrete ribs, which in themselves were of sufficient strength to carry the whole of the calculated loads. The cast-iron work remaining embedded therefore provided additional strength up to its own limit. The outermost two of the three central ribs were, moreover, designed to carry the whole of the load, the inner rib being encased in ferro-concrete merely for convenience. The plan will be readily followed on reference to Fig. 8, page 251, which shows a half arch in elevation, whilst transverse sections through different points are reproduced in Figs. 9 to 13. The width of the reinforcement and the arrangement of the steel bars, is clearly shown in these figures.

Owing to the increased loads for which the new structure was designed and also to the greater dead-weight to be carried, it was thought that the old cast-iron plates on the abutments would not be sufficiently strong for future requirements, and consequently a deep ferro-concrete distributing beam was provided running along each abutment at the springing of the arches, the depth of this beam being about 5 ft. 8 in., and its width 24 in. This distributes the load upon the masonry so as to reduce the stress to about 7 tons per square foot. A section through this beam is represented on the right of Fig. 8. It was thought that the old abutments would be sufficiently strong provided that they were excavated behind and backed with mass concrete in the manner indicated to the right of Fig. 6.

The old cast-iron plate decking was removed and spandrel walls built up from the new ribs to deck level (see Fig. 9), encasing in their depth the original cast-iron lattice work which gave support to the cast-iron decking. The arched ribs were stiffened and connected laterally by means of the original cast-iron struts encased with concrete, and reinforced with four steel bars of $1\frac{1}{8}$ in. diameter.

A new ferro-concrete decking 7 in. thick is provided, carried upon secondary beams spaced at about 4 ft. centres, and resting upon the three parallel spandrel walls and the crowns of the three arches. The secondary beams are continued on each side of the bridge as cantilevers up to the backs of the original cast-iron arched ribs (see Fig. 10) which previously came immediately beneath the parapet and formed the face of the work. These arched ribs, with the inscription referred to above, are not encased or changed in any way, but still remain in full view and in their original positions. As it was also found desirable to increase the total width of the bridge, as well as to strengthen it, it was decided that the new roadway should be 20 ft. wide and that there should be two overhanging footpaths of 4 ft. width. It is clear that the cantilevers running from the secondary beams could not be prolonged to the full width of the new bridge without passing through and thus spoiling the appearance of the external cast-iron ribs. Consequently, the ends of these cantilevers are coupled up by means of ferro-concrete beams running parallel with the axis of the bridge and immediately behind the cast-iron face ribs (see Fig. 10), and at this point the decking itself extends out further in cantilever form on each side, with no ribs beneath it. The outer end of this projecting cantilever forms a cornice to the bridge and a kerb or plinth in ferro-concrete springs from it 8 in. back from the face. The railings, from the original bridge are re-set in this kerb, (see Figs. 9 and 10) and, consequently, with the exception of the footpaths overhanging the cast-iron face ribs, the bridge still presents its old features to the general view, although it is 8 ft. wider and strengthened to take modern heavy loading (see Figs. 4 and 5, page 262).

The strengthening was carried out in two halves longitudinally to enable the bridge to be used without a break. The plan adopted will be clear on reference to Figs. 15 and 16, page 252. On the same page, Fig. 17 shows the method of supporting the ribs whilst the works were in progress.

The design of this bridge had been practically settled before the current standard loadings of the Ministry had come into use, and the test load used in proportioning the parts is represented in Fig. 14.

LITERATURE.

The Jutland Scandal. By ADMIRAL SIR REGINALD BACON, K.C.B., K.C.V.O., D.S.O. Messrs. Hutchinson and Co. [5*s.* net.]

ADMIRAL BACON'S book has been well conceived. Being impressed by the very unfair criticism to which Admiral Lord Jellicoe has been subjected, and realising that the board of Admiralty has issued an official narrative of the battle of Jutland, which tended to encourage adverse judgments upon Lord Jellicoe, Admiral Bacon determined to set up a scientific, reasoned defence of the ex-Commander-in-Chief. He has succeeded admirably. The book falls into three divisions: first, Admiral Bacon subjects the popular conception of Nelsonian tactics to a historical analysis; secondly, he explains modern battle tactics, and the use of various types of warship in modern war; thirdly, he applies the results of his analysis to the tactical problems of the battle of Jutland.

Admiral Bacon proves, to the satisfaction of every thinking person, that Nelson's gifts of leadership have been very much misunderstood. In the popular fancy, Nelson was a man who was perpetually taking huge risks successfully; a dispassionate examination of the real facts shows that the navy of republican France was not our equal in training, seamanship or equipment, and that Nelson's two great victories were the victories of good seamen over bad ones. Nelson's great merit consisted in the care and skill with which he thought out tactical plans, which made it quite sure that our advantages were always exploited and never thrown away. The true character of Nelson's leadership has for long been understood by serious students of naval history; none the less, Admiral Bacon has done a great service in attacking a popular superstition so unflinchingly. He is quite right when he says that the generally accepted view of Nelson's leadership at the Nile and Trafalgar has inspired a great deal of unjust criticism of later British naval commanders.

Admiral Bacon's explanation of the problems of deploying a fleet, of launching and avoiding a torpedo attack, is extraordinarily lucid; he deserves special congratulation for manufacturing such explanatory phrases as "follow-your-leader" and "tooth-comb" formations. The professional equivalents of "single line ahead," and "divisions in line ahead columns disposed abeam" would not have been comprehensible to the non-professional reader, whom Admiral Bacon wished to reach; to have thought out these homely phrases, and used them with such effect shows a rare literary talent. It should be added that the book's great title to popularity rests in the simplicity with which Admiral Bacon approaches the general reader. There is nothing pontificial about him; he has no wish to make naval tactics an obstruse science. His main theme is indeed overwhelmingly honest; a good naval tactician can quite easily impart his knowledge, but not his experience; for that is an accumulation of personal qualities, built up by time and hard work.

The charges levelled against Admiral Jellicoe's conduct at Jutland can be summarised as follows: (i) That his deployment was not calculated to bring on a decisive action; (ii) that he was over-cautious in avoiding Admiral Scheer's torpedo attacks; and (iii) that he took no heed of facts which sufficed to prove that Admiral Scheer was making for Horn's reef, during the night, and so let him escape. Admiral Bacon has no difficulty in disposing of these three accusations; indeed, as he admits, the relevant facts have for months past been before the public; they only lacked a commentator. As for the deployment, no alternative method would have given Admiral Jellicoe the advantages he was seeking to secure—an initial gun action, as free as possible from disturbance by torpedo attacks, on a course roughly parallel to the enemy's. In addition to this, deployment on the left wing was the only way of bringing all the broadsides to bear during the deployment itself. By deploying on the other wing, or the centre, the deploying columns would have had their fire masked until they had got into line. As it was, nothing but the mist and haze prevented the whole fleet from keeping Admiral Scheer's line under fire whilst deployment was actually in progress.

With regard to the second charge, the evidence is overwhelming that in 1916 all naval commanders, British and German, turned away from torpedo attacks. The question was examined by an anonymous writer in the 1924 edition of Brassey's Naval Annual, who quoted eight instances of similar turns away from torpedo attacks. His conclusion, which is identical with Admiral Bacon's, is that "the movement was simply a recognised counter to a known danger. The only difference between German and British practice seems to have been that, in like circumstances, their turns were roughly double ours."

On the third accusation, Admiral Bacon proves that Lord Jellicoe was told nothing, and saw nothing which remotely suggested that Admiral Scheer was passing behind him during the night of May 31. Several ships in the fleet noticed the flash of guns astern, and noticed, also, that each successive outburst of firing was to the eastward of the last. All, or practically all, the captains who saw this concluded that the destroyer screen astern of the grand fleet was heavily engaged, as was indeed the case; but they did not know that the flotillas were in the presence of enemy battleships, and this would have been the decisive knowledge. The two captains who did sight enemy battleships during the night did not report it to Admiral Jellicoe; and the Admiralty neglected to let him know that Admiral Scheer had ordered an airship reconnaissance off Horn's Reef at daybreak on June 1. Obviously, then, the Commander-in-Chief was not in possession of those facts which alone would have justified him in making for Horn's Reef during the night of May 31.

Having satisfactorily disposed of these various accusations by a genuinely scientific survey of every point at issue, Admiral Bacon compares the merits of the two principal naval commanders at Jutland. As might be expected, he concludes that Admiral Jellicoe was the better man. This, however, is the least interesting part of the book, and it should be said that it would have been better if Admiral Bacon had defended Admiral Jellicoe without attacking Admiral Beatty. Admittedly, the temptation was great. The German staff history has proved how ill the battle of the Dogger Bank was fought by our ships, how poor their gunnery was, and how feeble was our leadership. Admiral Bacon knew that the blame for what had occurred had been placed on a perfectly innocent person; and he knew that the Admiralty narrative of the battle of Jutland was pregnant with *suggestio falsi*. All this, it seems, made him indignant, and he has hit out. As his reply is quite disinterested, and made not on his own behalf but on that of a brother officer, it commands sympathy. None the less, it would have been even more telling had it been less personal. Also, he would have been better advised had he given more publicity to articles which support Admiral Jellicoe's case, and less to an isolated newspaper article which supported Admiral Beatty's. This, however, is not said in any cavilling spirit; there is no other book on sale in England which explains the facts so lucidly, so candidly, and with so little assumption of superior knowledge. Since it has been published nobody in the English-speaking world has a right to complain that he cannot understand the greatest naval battle of modern times because the explanations given are beyond him.

The Thermionic Valve and its Development in Radio-Telegraphy and Telephony. By J. A. FLEMING, F.R.S., Professor of Electrical Engineering in the University of London. Second edition, fully revised. London: The Wireless Press, Limited. [Price 15*s.* net.]

Thermionic Tubes in Radio-Telegraphy and Telephony. By JOHN SCOTT-TAGGART, F.Inst.P., A.M.I.E.E. Second edition. London: The Wireless Press, Limited. [Price 15*s.* net.]

THE development of radio-signalling, though astounding, has quickly been accepted as one of the facts of daily life. Radio-telegraphy found telegraphy and telephony firmly established, in the public service as well as in our houses. To modern children, talking on the telephone is as simple as switching on a lamp, and after playing with an electric bell they soon begin to rig up radio sets.

When they wish to instruct themselves about what they are doing, they find plenty of books which, it must be acknowledged, frequently offer more sound information than is to be found in volumes on some other fields of applied science written "up to date."

Books like Professor Fleming's "Thermionic Valves" and Mr. J. Scott-Taggart's "Thermionic Tubes" are, of course, of the kind of which one expects something, and the reader will not be disappointed. The two volumes are nearly of the same compass, and both are well illustrated, and they cover the same ground much in the same way, and yet each in its own way. Professor Fleming speaks of valves, Mr. Scott-Taggart of tubes. The former term seems preferable; it is distinctive, and there are too many tubes already, and even X-ray bulbs have often to pass as tubes. Professor Fleming opens his first chapter on scientific principles with detectors of electric waves, and proceeds to the Edison effect of 1883 and his own researches on that effect. Mr. Scott-Taggart begins his first chapter on two-electrode valves and the theory of thermionic currents with the systematic researches of Elster and Geitel (1882) on thermionic emission. Both the authors soon come to the discovery of the electron by J. J. Thomson. Professor Fleming's chief chapters are headed the Fleming rectifying valve; the three-and-four electrode valve, its theory and construction; thermionic valves as generators, amplifiers and detectors, as repeaters and relays; a chapter on thermionic valve testing is interposed, and the last chapter on valve plant describes various stationary and portable sets. Mr. Scott-Taggart has a larger number of chapters (17 against 12); his sequence is detectors, amplifiers, multi-stage amplifiers and retroactive circuits, reception and transmission measurements, the vacuum tube in wireless telegraphy, miscellaneous tube devices and recent developments; in his last chapter he describes the mechanical reaction relay which he brought before the British Association at Liverpool in 1923 and which we mentioned at the time.

In both the volumes we find many diagrams of practical working arrangements. Mr. Scott-Taggart, whose illustrations come up to 388, also notices some special American circuits. The dynatron, a valve which serves as a negative resistance and as a generator and amplifier, is described by both the authors; the negatron and pliotron, inventions of Mr. Scott-Taggart, only by the latter. It is convenient to distinguish peculiar valve connections by special names; but the names mentioned, and further the pliodynatron and kenotron, are not fortunate selections. Dull emitters seem to be noticed, and very briefly, only by Professor Fleming. Recent methods of determining the characteristics of valves do not appear to have received particular attention by either author, but both the volumes will be found very useful.

The Fatigue of Metals. By H. J. Gough, M.B.E., B.Sc. London: Scott, Greenwood and Son. [Price 25*s*.]

Engineers should feel indebted to Mr. Gough, of the National Physical Laboratory, for this book. No one engaged in the design of machines or structures can afford to ignore the great mass of data already collected on fatigue, but few have time or opportunity to sift the material for themselves, or, making use of the author's phrase, to put together the available parts of the "jig-saw puzzle." The author does this with considerable skill and clarity. The importance of considering fatigue is well illustrated by the table on page 52, giving the approximate service required of various structural and machine parts. From this table it appears that a steam turbine shaft has to withstand about 15,000 million repetitions of stress during its normal lifetime, and even the comparatively quiescent upper chord of a railway bridge sustains about 2 million repetitions.

The book, after a foreword by Dr. Stanton, opens with a short historical introduction, and it is interesting to find here an illustration of Fairbairn's apparatus for testing a built-up wrought iron girder under repeated loads, which calls attention to the fact that very few fatigue experiments have been carried out on built-up members in spite of the growing importance of this subject, especially in the design of metal aeroplanes. Chapter 2 contains a very complete account of the various types of machines used in fatigue testing, and author and publisher are both to be commended for the clarity of the illustrations showing the principles of action of these machines.

The problem of the endurance limit is next considered, and it is shown that an analysis of available data indicates the existence of a real endurance limit for an indefinite number of reversals. The curves on pages 56 and 57 display this very clearly. The "human endurance" curves, given on page 51, are, however, of doubtful utility in this connection—the analogy is rather a dangerous one. Chapter 4 shows that Goodman's and Gerber's Laws do not always give even a safe range, and the succeeding chapter contains a most interesting account of the effects on the fatigue range of form and surface finish, type of testing machine used, speed of test and sequence of tests.

The work of various investigators on the effects of scratches and surface irregularities is fully considered, and attention is directed to many important practical points, such as the good effect obtained by polishing connecting rods, and the folly of stamping inspector's marks on valve springs and other engine parts subjected to fatigue. Evidence is also given of the weakening effects of screw-threads on machine parts. In dealing with the various criteria of elastic failure, Haigh's recent hypothesis that elastic failure occurs when the strain energy absorbed by the material in virtue of its elastic strain exceeds a certain value, receives adequate attention in addition to the usual criteria.

Elastic hysteresis, Bauschinger's theory of the "natural elastic limits" and Bairstow's classic experiments in support of this theory are treated fully, and then an attempt is made to correlate the fatigue range with other tests. The only approximate relation of any value seems to be that the ratio of the limiting stress in reversed bending to the ultimate tensile strength is about 0·46 for wrought ferrous metals with a possible ± error of about 10 per cent. This is useful for economy of specimens in fatigue experiments, but the author comes to the sound conclusion that no single method of test will disclose all the properties of a material. It thus becomes of importance to find a test that will determine the fatigue limit quickly, simply and cheaply, and this is taken up in Chapter 10, where Smith's strain method and Stromeyer's calorimetric method are described, and it is shown that recent experiments, while generally upholding the soundness of these methods, indicate that no rapid way has been yet devised that will *always* give trustworthy results, especially in specimens containing flaws. The discussion ends with a proposal that engineer's acceptance tests for materials should include a simple endurance test on a machine of the Wöhler type.

Mr. Gough has throughout considered the phenomena associated with static stresses together with those of fatigue and in the chapter on the fracture of metals, chapter 8, shows that fracture under repeated stresses has many features in common with fracture under static loads. He points out the error of the popular idea that a "brittle" fracture results from the fatigue of a ductile material and discusses at length, with the help of an excellent series of photographs, the physical reasons for the manners of failure exhibited by metals under different conditions and the effect of flaws.

The author rightly remarks in dealing with quick methods of test that "no method will be really successful until a theory of fatigue is evolved" and this is perhaps the crux of the matter. The evolution of the subject of fatigue roughly exhibits, in multiplied and telescoped form, the same stages as the evolution of the planetary theory. There is a huge mass of experimental data more or less analogous to the work of Tycho Brahe; there are a few empirical laws, such as the Bauschinger theory of the natural elastic limits, corresponding more or less to Kepler's Laws; but only of recent years has a real start been made towards the discovery of the underlying physical laws governing the phenomena observed. Chapter 9 deals with the present state of knowledge in the latter field. The author expresses the opinion that this chapter will probably become out of date very quickly. He is undoubtedly right, but it is at present perhaps the most fascinating in the book. After stating his opinion that the two phases, crystalline and amorphous, should be studied separately, he goes on to discuss the beautiful experiments of Taylor and Elam on strained single crystals under X-ray analysis, of Beilby on the phase changes, of Griffiths on the tensile strength of materials and the theories of Beilby, Rosenhain, Haigh, Griffiths and others, concluding with an account of his own theory. Although it may be said that "the best in this kind are" as yet "but shadows" there are already signs that the substance will not long be lacking. It appears possible that work now in progress on the fatigue of non-metallic substances, an important subject not considered in this book, may also throw some light on the physical nature of fatigue.

References are placed at the end of the book in the form of a bibliography. A few mistakes have been noticed in the reference numbers in the body of the work, but they are not likely to mislead the reader. A most useful and elaborate appendix gives comprehensive tables of the mechanical properties and fatigue data of metals classified in a novel manner and in every case all details that are obtainable of the analysis and heat-treatment of the specimens are added.

The book is well produced and illustrated, but the frontispiece of an aircraft engine with its accompanying legend suggests an appeal for popularity rather akin to the sensational "jackets" that some publishers seem to find necessary for even the most serious works and is unworthy of this important book. Perhaps it might have been left out and the price somewhat reduced.

THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

(*Concluded from page* 236.)

In Fig. 3 we illustrate a fatigue-testing machine for tests of the "Wohler" type, forming a further exhibit on the stand of Messrs. W. and T. Avery, Limited. It will be seen from the illustration that the machine consists of a bed, on one end of which is mounted a driving gear for rotating the specimen to be tested, and on the other a loading gear which is connected to the end of the test-piece through the medium of a shackle. By this means cantilever loading can be applied to the specimen while it is being rotated. The machine is driven by the direct-coupled electric motor seen on the left-hand end of the table. The speed of this motor can be regulated between the limits of 1,000 r.p.m. and 2,000 r.p.m. by means of the rheostat mounted on the vertical column carrying the weight bar. The headstocks are fitted with ball and thrust bearings, and a ball bearing is also fitted in the shackle which connects the specimen to the steelyard. A trunnion is provided in the shackle to permit free movement of the specimen under deflection, while allowing the connecting rod to give a vertical pull to the steelyard. The specimen is driven by a split collet in the driving head of the machine. The counting mechanism can be clearly seen in the illustration, and is of the usual type driven by worm gearing from the driving shaft. The breaking of the specimen automatically cuts out the motor by means of a switch contact mounted on the end of the steelyard, which is operated by the fall of the latter. The steelyard is graduated to 100 lb. by 1-lb. divisions, the poise being propelled by a hand wheel through gearing and a screw. A loose weight can be hung on the end of the steelyard to increase the capacity of the machine to 200 lb. A pointer is connected to the steelyard to indicate the amount of deflection by 0·0002 in. on the specimen, for successive increments of load as produced by the movement of the poise. By this means the limit of proportionality is clearly defined. The test can also be carried to the point of fracture by running the specimen under a specified load. The number of revolutions shown by the counter before fracture takes place is a measure of the fatigue strength of the material. A special

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

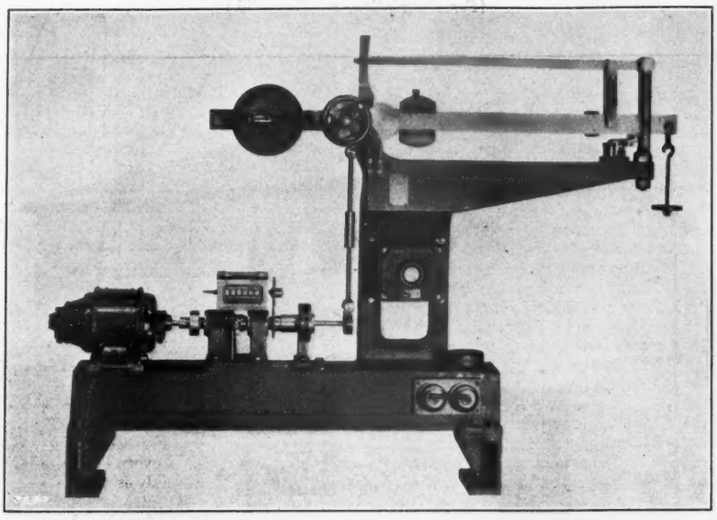


FIG. 3. FATIGUE TESTING MACHINE; MESSRS. W. AND T. AVERY, LIMITED.

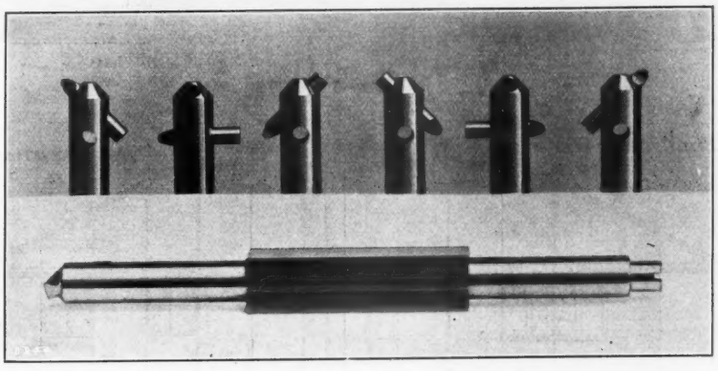


FIG. 4. NULOK TOOLHOLDER; THE EXE ENGINEERING COMPANY, LIMITED.

limit gauge is supplied with each machine for turning the specimen to the exact size required.

In dealing with the exhibits of the Exe Engineering Company in our last issue we omitted to refer to the Nulok tool-holder, of which this firm are the sole manufacturers. We illustrate the holder in Fig. 4, from which it will be seen that it consists of a central bar sliding in a tubular member, the tool passing at an angle through both the tube and the central bar, and being locked in position by means of the screw shown at the outer end of the tool-holder. Turning this screw tends to draw out the inner bar from the tubular member, and thus locks the tool firmly in position. The outer member passes through the split square holder shown, and by nipping this in the lathe tool-holder, it will be evident that the tool can be set without any chance of slipping from its position during the process of tightening up, and at any desired angle.

One of the most interesting exhibits at the fair was a pair of "Telford" all-steel houses, shown by Messrs. Braithwaite and Co., Limited, of Crown Bridge Works, West Bromwich. A pair of these houses can be completed ready for occupation in the remarkably short time of ten days after the laying of the concrete flat. The houses are eligible for the subsidy under the Housing Acts of 1923 and 1924 on application being made by the authority or individual proposing to erect. All parts of the houses are prepared in the factory and despatched marked ready for erection by the purchaser, and the erection may be performed by utilising unskilled labour. Pipes for water, gas, or electricity are already fixed to the plates and have only to be joined up by a screwed union.

We illustrate a pair of these houses in Fig. 5 and various details in Figs 6 to 14 on pages 256 and 257. It will be clear that the form of construction adopted permits of considerable latitude in design, and that the illustrations that we give merely show one typical arrangement. The plates used throughout are flanged, and thus, in addition to forming the walls, are sufficiently rigid when bolted together to provide both the vertical and horizontal weight sustaining members for the entire structure. The house is erected on a concrete platform, which is clearly seen in Fig. 13. Ragbolts are inserted in the concrete, and the flanged plates which form the outer walls of the lower storey are secured to the platform by this means. These plates, which are 3 ft. 6 in. wide, extend vertically to the full height of the room, and after the insertion of the door and window frames are bolted together along their vertical joints. A horizontal stringer course, which may be seen in section in Figs. 10 and 13, is then bolted to the sections, tying the whole of the walls together at the first floor level. A number of flitch beams are then placed in position resting on the horizontal tee, these constituting the floor beams for the upper storey. These beams bridge the full width of the structure, and do not receive any support from the interior walls dividing up the ground floor into rooms. The method of construction of the upper storey is similar to that of the lower, the roof being bolted to the top flanges of the first storey plates. The general construction of the roof can be seen in Figs. 6, 7 and 10, and from these it will be clear that it is built up from plates in a similar manner to the walls. The ridge piece is an inverted steel channel, and this terminates at each end in cast-iron breeches pieces, from which four similar channels are carried to cast-iron corner shoes, thus producing the hips. The chimneys and flues are cast iron throughout, the method of sealing the chimneys in the chimney boxes being clearly seen in Fig. 10. The whole of the plate joints throughout the building are sealed with mastic, and the outside of the building is then given three coats of paint, the last coat being elastic. The method of inserting the door and window frames in the steel plating is shown in Fig. 14, and the same figure shows the method of fastening the asbestos sheets, which form the inner lining of the outside walls, to the wooden framing bolted to the steel outer plates. The inner face of the steel is protected against rust by a bitumastic or other solution. A 6-in. cavity is left between the outer plates and the inner asbestos sheet lining. This space is continuous with that under the roof, but is otherwise entirely sealed, and will have a marked effect in maintaining an even temperature in the interior of the house. The wall between a pair of houses is constructed of steel plates in a similar manner to the outer walls, but otherwise the partition walls consist of asbestos sheets fastened by hard wood fillets to a wooden framing. The interior walls are thus broken up into panels, which may be distempered or papered as desired, the fillets being stained dark oak. The windows are of the steel casement type in wood frames, the doors and all the interior fittings being in wood.

The chimney breasts, of which sections are given in Figs. 11 and 12, are of steel construction similar to the main walls, the chimney flues being cast iron. As the latter pass through the roof space, which, as explained, is continuous with that between the outer and inner walls, they should assist in keeping the houses warm in winter. The usual types of fire grates and ranges are used boxed into the steel linings. A complete hot-water system, supplied from the kitchen range, is carried to various points throughout the house, thus allowing for airing cupboards, drying rails, or other conveniences as desired.

Figs. 5 to 14 inclusive show the lay-out of a small non-parlour type of house, but, as we have already explained, the form of construction from standard units allows wide freedom in planning. Standardised bay windows are available when required. The ground floor may be finished with boarding secured to creosoted fillets let into the concrete, the boards being also creosoted on their under sides, or the concrete may be covered with an approved composition floor for the living rooms, and a cement or granolithic paving or cast concrete slabs laid in other places. The upper flooring consists of wood board nailed to the flitch beams in the usual way. The ceilings of both storeys are made up with asbestos or other sheeting as desired.

Considerable criticism has been levelled at steel houses on the ground that they must have a very short life, but there does not appear to be any reason why the Telford house which we have described should not last almost indefinitely, providing it is given the usual maintenance of any steel structure exposed to the weather. The makers suggest that it would be advisable to repaint the outside after the first three years, and subsequently at five-year intervals, and this should be almost the whole of the maintenance required. We may say in conclusion that the design of these houses is due to Mr. J. C. Telford, M.Inst.C.E., the general manager and director of Messrs. Braithwaite and Co., and that the plans have been prepared by the consulting architect to the company, Mr. H. E. Farmer, F.R.I.B.A.

A number of other firms showed interesting exhibits, which our space does not permit us to discuss in detail, but with some of which we hope to deal at a later date. Amongst these may be mentioned Messrs. Ruston and Hornsby, Limited, who were showing a 110-brake horse-power airless-injection, vertical, twin-cylinder, enclosed-type engine and a 2½-kw. petrol-paraffin lighting set; Messrs. Charles Purden, Limited, who exhibited fans for blast furnaces and similar purposes; Messrs. J. Broughton, showing automatic guards for

power presses; the Star Foundry Company, Limited, on whose stand were shown excellent examples of fine castings in soft grey iron; Messrs. William Allday and Co., Limited, showing a large range of fans and blowers for various purposes; and the Wolseley Sheep Shearing Machine Company, Limited. The latter showed 4-h.p. and 6-h.p. petrol and paraffin engines for general farm work and electric lighting plants, which appeared to be a particularly sound job. A number of different firms, members of the Association of Drop Forgers and Stampers, showed a wide range of drop forgings, amongst which a number of motor-cycle and domestic fittings in stainless iron were particularly noticeable. A number of other firms were exhibiting small tools, amongst which we saw an interesting taper twist drill, on the stand of the Rapid Cobalt Company, designed for dealing with taper-pin holes in sizes 0 to 10. These were formed to cut all the way up the spiral and eliminate the tedious operation of reamering out small holes by hand. The fair closes to-day.

THE LATE SIR EDWARD THORPE.

SIR EDWARD THORPE, F.R.S., for many years professor of chemistry at South Kensington, and further principal of the government laboratories in Clement's Inn, who died on Monday, at Whinfield, Salcombe, South Devonshire, in his 80th year, did not limit his activities to chemistry. His magnetic survey of the United Kingdom which required a man of wide knowledge, was as remarkable as his eminent chemical work, and he took part in several eclipse expeditions.

Born on December 8, 1845, as son of a Manchester merchant, Thomas Edward Thorpe was educated at Owens College, studied at Heidelberg under Bunsen and at Bonn, became Roscoe's assistant at Owens College, taught in Glasgow and Leeds, and was in 1885 appointed professor of chemistry in the Royal College of Science, South Kensington, where he remained until 1894, when he went to the Government Laboratories which greatly extended their scope under his guidance. Originally analysts to the Revenue Department, the Laboratories took up varied problems. Thorpe demonstrated that the stringent rules regarding the use of lead in the potteries and elsewhere might be relaxed in certain directions without prejudice to the welfare of the workers, and he originated in 1903 the electrolytic test (based upon an old suggestion made by Fischer in 1812) for traces of arsenic in beer and food stuffs at the time of the beer-arsenic scare. When he retired from the Government Laboratories, in 1910, he returned to the Imperial College of Science as director of the chemical laboratories.

His selection as British member of the International Committee on Atomic Weights was a tribute to the high accuracy of his work. He had determined the atomic weights of gold and titanium; later he redetermined the atomic weight of radium and of strontium. In the former case he had half-a-ton of pitchblende from Joachimstal at his disposal from which he extracted 1 lb. of mixed barium-radium chloride, which he fractionated by 9,400 crystallisations. This work was the subject of one of his three Bakerian lectures to the Royal Society. The second was his magnetic survey of the United Kingdom, on which he engaged with the late Sir Arthur Rücker in 1884 to 1888, and which he supplemented by a second survey in 1889, and by magnetic work elsewhere. During the first period of four years he took observations at 205 stations. The third Bakerian lecture given jointly with Mr. J. W. Rodger, was on viscosity and the chemical nature of liquids. The first of his eclipse expeditions took him to Sicily in 1870 and the ship, H.M.S. Psyche, struck a reef near the Arcireale promontory, a lava rock south-east of Etna; on the fourth eclipse expedition of 1873 to West Africa, of which he was leader, his ship was wrecked.

Thorpe was President of Section B, Chemistry, of the British Association, at Leeds in 1890 and President of the Association at Edinburgh in 1921. In his address at Leeds, he vindicated the claims of Joseph Priestley to the discovery of oxygen, 1774, and of Cavendish to the discovery of hydrogen, 1783, against Lavoisier, whose priority had been reasserted just then by Marcelin Berthelot. Lavoisier had heard of Priestley's experiments from Priestley himself and of Cavendish's from the latter's assistant, Blagden. Thorpe's address at Edinburgh was more noteworthy as a historical review—appropriate at the 90th anniversary meeting of the Association at York—than as a broad survey of modern views on "the inner mechanism of the atom," and further for his vehement denunciation of poison-gas warfare. His "Essays on Historical

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

(*For Description, see Page* 255.)

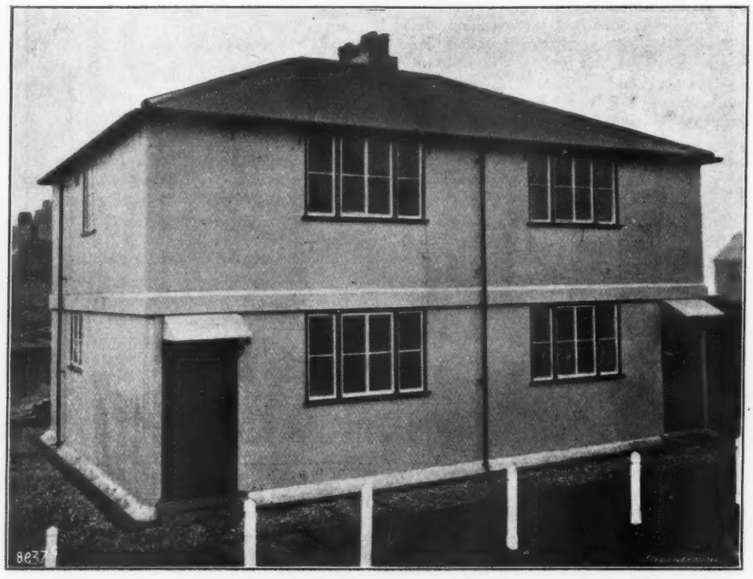
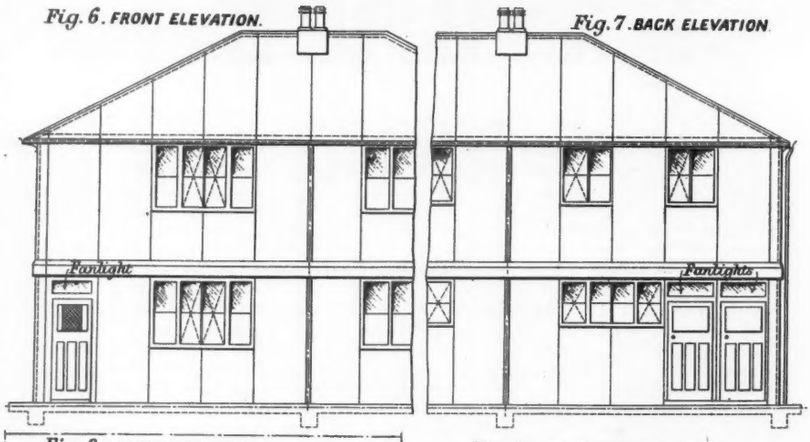
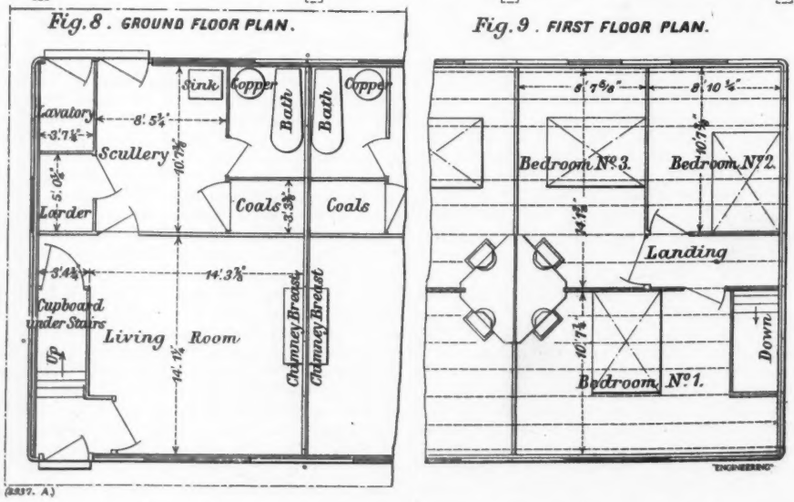


FIG. 5.





FIGS. 5 TO 9. STEEL HOUSES; MESSRS. BRAITHWAITE AND CO., LIMITED, WEST BROMWICH.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

(*For Description, see Page 255.*)

Fig. 10.

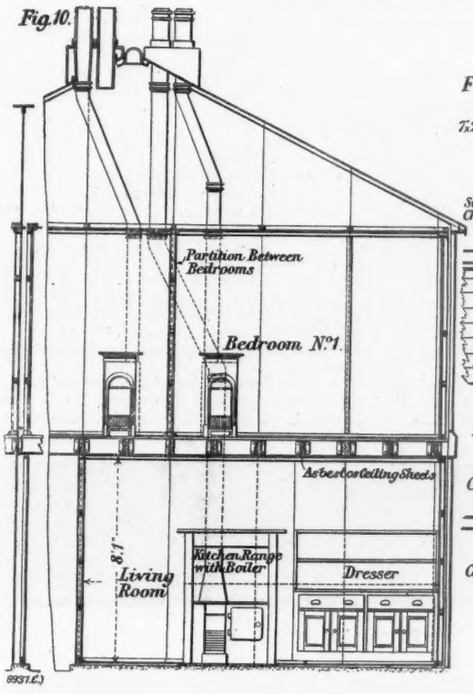


Fig. 11. SECTION THRO' BEDROOM CHIMNEY BREASTS.

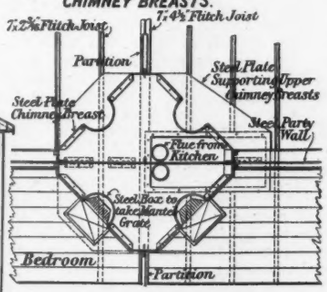


Fig. 12. SECTION THRO' KITCHEN CHIMNEY BREAST.

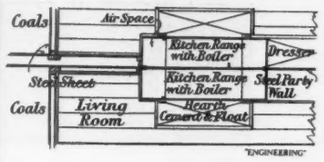


Fig. 13.

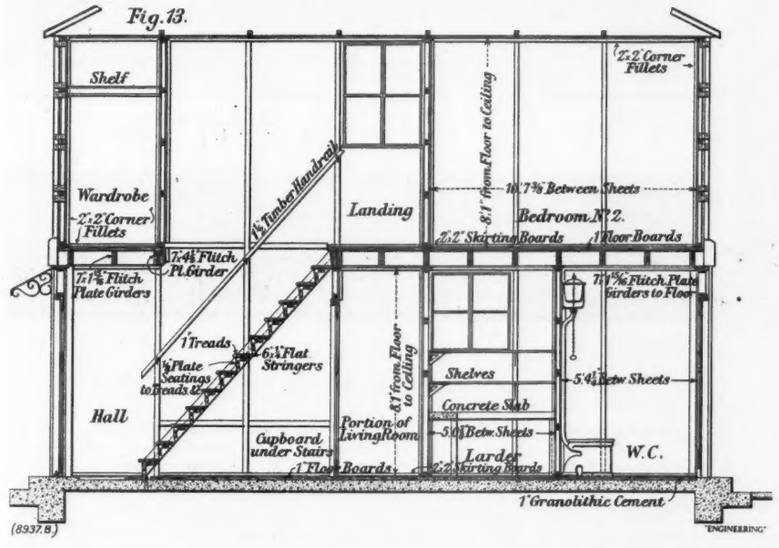
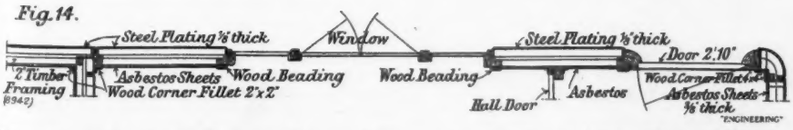


Fig. 14.



FIGS. 10 TO 14. STEEL HOUSES; MESSRS. BRAITHWAITE AND CO., LIMITED, WEST BROMWICH.

Chemistry" and his "History of Chemistry," testify to the historical interests of this genial and popular worker and lecturer. The "Dictionary of Applied Chemistry," edited by him, the first volume of which dates from 1890, is now almost complete, except the sixth volume, in its second edition. Thorpe was President of the Society of Chemical Industry in 1895, and of the Chemical Society, which had awarded him its highest distinction, the Longstaff Medal, in 1899 to 1901; he was for some years foreign secretary of the Royal Society, and held honorary degrees from many foreign Universities. The beautiful house in which he died he had built himself near the sea, being an enthusiastic yachtsman. He leaves a widow, Caroline Emma, daughter of Dr. John Watts, of Manchester.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The Council of the Institution of Electrical Engineers have decided to accept in lieu of Part I of the examination for associate membership the Higher Grade National Certificate or Diploma in electrical engineering provided the candidate satisfies the institution in the subject of an English essay.

THE DALBY - WATSON INDICATOR FOR HIGH-SPEED PETROL ENGINES.

AT a meeting of the Institution of Mechanical Engineers (North-Western Branch) held in the Engineers' Club, Albert Square, Manchester, on Thursday, February 19, 1925, Mr. H. Wright Baker presented a paper entitled "Notes on the Use of the Dalby-Watson Form of Indicator for the High-Speed Petrol Engine." We reproduce this paper in abridged form below:—

The indication of the high-speed petrol engine presents many difficulties, and the present paper outlines an investigation of some of these problems.

The tests were carried out on a single-cylinder Armstrong-Siddeley unit,* using a cylinder differing slightly from the standard 1920 model and fitted with a port for the attachment of the pressure pipe. The indicator is of the Dalby-Watson diaphragm type, to which additions and modifications have been made, notably the provision of a camera for the taking of continuous records over a large number of consecutive cycles.

Indicator Mechanism.—In the indicator as received, the gas pressure was taken from the cylinder by a rigid steel tail-pipe terminating in a chamber closed by the diaphragm and partially filled with copper baffle plates and nickel gauze. Owing to the comparatively large volume of the chamber, the gauzes nearest the engine became incandescent, and pre-ignition could not be prevented, a smooth, but incorrect, diagram being obtained. After numerous experiments, the pressure chamber was replaced by a steel plate, turned and fitted exactly to the diaphragm, a clearance of 0·01 in. being then provided by the insertion of a lead washer. The tail-pipe at the entrance to the chamber was bell-mouthed to overcome the difficulty of erosion of the diaphragm experienced with a plain entrance.

Pre-ignition and diaphragm cracking having been eliminated, violent oscillations were recorded varying with the mixture strength and frequently attaining an amplitude equivalent to 200–300 lb. per square inch (see Fig. 1 on page 258), even with non-pinking petrol-benzol mixtures. The period of the oscillation is that of the diaphragm plate.

At the suggestion of Major Carter, of the R.A.F., a bent tail-pipe of copper, ¼ in. diameter and ⅛ in. bore, was fitted, and smooth curves were at once obtained. The results of many experiments indicate that the bent pipe, probably acting in the manner of a Bourdon-gauge tube, absorbs the waves of high pressure which may be formed in addition to the sustained pressure rise by combustion and may greatly exceed in speed the motion of the actual combustion front. By direct photography, Dixon and Campbell† have clearly shown the existence of these detonation waves, and the shattering of glass explosion tubes up to 10 mm. thick by explosions nominally at atmospheric pressure has indicated their magnitude. These investigators have also shown that the introduction of a flexible connection between two portions of the explosion tube destroys the detonation wave; but that, though reduced in velocity, the wave is not eliminated by changes of section, &c., a fact which may explain the apparent indifference of the wave to gauzes and baffle plates placed in its path. The greater inertia of the piston indicator will also act as an absorbent for such waves.

The tail-pipe used when taking the diagrams reproduced in the paper was ¼ in. diameter and ⅛ in. bore, hammered slightly oval and bent into a loop. The overall length was 2½ in. A long-period oscillation, noticeable early in the expansion stroke, appears to be produced by the pressure mirror suspension, probably through synchronism with the diaphragm.

Owing to erratic action, the epicyclic phaser was discarded and replaced by two 1-in. ball bearings mounted eccentrically on the engine shaft, one in phase with the crank and the other 90 deg. ahead. By means of a lever bearing on the roller thus formed, the vertical motion of one or other of the outer races is reproduced on a smaller scale in the steel wire driving the displacement mirror, while, by slight pressure on the lever towards the second ball race, the phase can be instantly advanced or retarded by 90 deg.

Two cameras have been in use. In the first, by which the illustrations in this paper were obtained, a dark slide, carrying five plates measuring 5 in. by 4 in., placed end to end, is traversed in a wheeled carriage across an aperture in the focal plane of the ray of light, the motion being uniform and controlled by clockwork. In the second, a similar movement is given to a 4-in. roll film by winding from a small reel on to a drum of large diameter, which is rotated electrically.

The diagrams so obtained are elongated in the outward direction of piston movement and shortened on the return strokes by amounts equal to one quarter

* Proceedings, I.Mech.E., 1923, page 1045.

† Phil. Trans. A 200, page 335, Trans. Chem. Soc., 1922, vol. cxxi.

of the displacement between the ends of two consecutive diagrams.

For the examination of individual diagrams, with reference to the general behaviour of the engine, mean diagrams were required. The phasing of the indicator was therefore changed half-way through the exposures, and ordinates were measured on the card at 10 deg. intervals over the central, or extended, portions of forty consecutive diagrams, twenty with normal phasing and twenty at 90 deg. advance. Mean diagrams were then drawn from the averages of ordinates for each crank-angle and plotted both on crank-angle and displacement bases. These diagrams are taken as representing the mean behaviour of the engine.

Examination of Diagrams: Irregularity.—The irregularity in height of consecutive diagrams, which may be noticed even in slow-speed gas-engine cards, becomes very marked with the high-speed petrol engine. The net irregularity is produced by a variation of pressure at ignition with irregularity of the explosion curve, corresponding with changing mixtures, as is shown later The following table indicates the magnitude of these variations :—

	Range of Variation of Pressure. Per cent. of Mean Pressure.	Number of Cards showing Pressures within ± 5 per cent. of Mean.
At ignition	9 per cent. at 1,000 r.p.m.	43 } mean values for 7 mixtures.
	35 ,, ,, 1,900 ,,	33 }
At maximum pressure	35 per cent. for $\frac{A}{P}$ = 9 : 1	30
	25 ,, ,, = 13 : 1	60–70 } 1,600 r.p.m.
	35 ,, ,, = 17 : 1	30

the percentage variation in area is from ½ to ¼ of the corresponding percentage variation in height, while for air-petrol ratios between 12 : 1 and 16 : 1 the extreme variation is only 1 per cent., decreasing to less than ½ per cent. for good mixtures. Reduced heat losses and increased pressure during expansion seem to compensate almost exactly for loss of area of the diagram early in the stroke. Figures from a trial made at 1,600 r.p.m., given in the table at the foot of the previous column, are reassuring.

For other reasons, however, the value of the indicator card as a means of determining the indicated horse-power is open to doubt. In these trials the difference between the I.M.E.P. (+ loop of diagram) and B.M.E.P. has always been greater than the friction and pumping M.E.P calculated from motoring tests, the excess varying from 11 per cent. of the I.M.E.P. at 1,900 r.p.m. to 6 per cent. at 1,000 revolutions. In addition to this error, the opening of the indicator cock causes a drop in brake horse-power of approximately 2 per cent. As the corresponding increase in compression space is less than 0·5 per cent. it would appear that the indicator has a distinct influence on the form of explosion. (The indicator connection leaves the cylinder at right angles to the diagonal containing the sparking plug.)

In order to provide an interpretation of the irregular form of the explosion curves, tests have been carried out at speeds of 1,900, 1,600, 1,300 and 1,000 r.p.m., and with air-petrol ratios varying from about 9 : 1 to 17 : 1.

Fig. 3 shows sections of some of the cards taken at 1,300 r.p.m., and Figs. 3A and 3B show the mean cards plotted from these and similar cards on time and volume bases. The mean explosion curves are taken as representing the action of the engine if supplied with a uniform mixture having the measured mean strength supplied during the trial. It was hoped to find some function of the explosion curve, obtainable with reasonable ease and accuracy, which could be used as a qualitative index of the mixture strength, keeping in mind also the possibility of using the relation in connection with later trials of carburettor action during acceleration, &c.

The simplest measurement is that of maximum pressure. Starting with a mixture of 9 : 1, this increases regularly to a maximum some 80 or 100 lb. higher with a mixture varying from 12·5 : 1 at 1,900 r.p.m. to 13·5 : 1 at 1,000 r.p.m., after which it falls to the initial value at 17 : 1. Curves of still greater regularity may be obtained by considering the pressure increase from ignition. The maximum pressure, however, is not a distinctive factor when considering varying speed, 1,600 r.p.m. giving the greatest pressures and 1,900 r.p.m. the lowest.

In considering the nature of a suitable factor, the following points should be noted :—(1) The factor should include a function of the time interval during which combustion and compression act simultaneously, and (2) periods of high heat loss, or during which the rise of pressure is retarded by an outward movement of the piston, should be avoided as far as possible. By plotting the time interval between the passage of the spark and the attainment of maximum pressure against mixture strength, curves of fair regularity are obtained, and these also show a regular variation with engine speed. [It is interesting to note, in passing, that, with the spark advanced to its best position, the time interval between ignition and top dead centre is almost constant for the range of speed investigated, that is, about 0·0045 secs.]

From the second of the above considerations, the choice of factor would appear to lie between the pressure rise in a given short time interval from ignition and the time required for a limited pressure rise. An interval of 0·007 second could be used for the range of speeds investigated (see Fig. 4), this being sufficient to allow accurate pressure readings to be obtained at 1,000 r.p.m., though at high speeds the peak of the diagram is partially included, this being probably the most unreliable portion of the card. In addition, for tests carried out during acceleration, the scale used in measuring the fixed time interval would have to be varied for each diagram on the card. The accuracy of measurement is also much reduced at slow speeds and part throttle.

Fig. 5 shows the variation of time interval for a rise of 200 lb. from ignition. The curves are of a fairly high order of regularity, and the requisite measurements

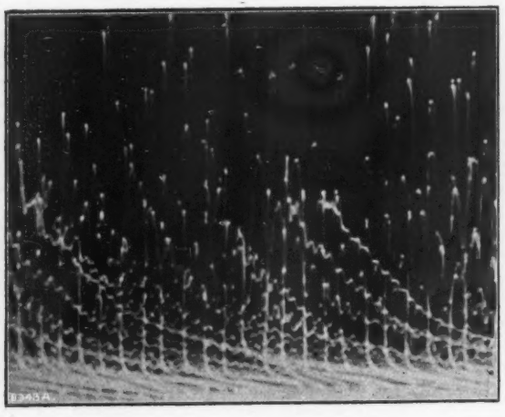


Fig. 1. Continuous Card. Phase—Normal.

Air-Petrol Ratio 8·6 : 1.

Air-Petrol Ratio 13·6 : 1.

Air-Petrol Ratio 17·1 : 1.

Fig. 3. Tests with Varying Mixture Strength at 1,300 r.p.m.

The variation of ignition pressure with mixture strength is very similar to the variation of maximum pressure, though the latter shows no continuous variation with speed, being least at 1,600 r.p.m., which has been found, in practice, to be the speed most easily maintained constant during trials.

There does not appear to be any definite cycle of variation, extreme cards appearing either consecutively or separated by several cards showing intermediate values.

Should variations of similar magnitude be experienced in the area of the diagram, the indicated horse-power determinations made from one or more cards taken at random would be valueless. Investigation

Area (in.²) of diagrams.	Time for 200 lb. rise from spark.	Calculated $\frac{A}{P}$ ratio. (Fig. 5).	Height.	Remarks.
	Second.			
Max. 4·46	0·0080	16·6 : 1	6·2	60 per cent. of cards within.
Min. 4·49	0·0063	13·0 : 1 Measured mean 14·8 : 1	7·4	±5 per cent. of mean height.

shows, however, that for extreme mixtures, that is, those giving a maximum pressure 45 deg. or more after top dead centre with normal spark advance, on the cards can be made with accuracy. Similar curves have been obtained for lower pressure-rises, for use when the diagrams are greatly reduced in height by throttling, though an additional factor is involved for part throttle tests owing to reduction of pressure and variations of turbulence. It will be noted that, at a given speed, a single time-interval is consistent with two mixture strengths, but by an examination of two or three consecutive cards and a knowledge of the measured mean mixture strength, the alternative mixture is easily eliminated.

To make use of these curves, the continuous diagram to be examined is covered with a sheet of clear glass ruled horizontally with the scale of pressures. On this rests a second glass scale divided into crank-angles, and carrying also the angle of ignition. The volume scale is adjusted so that its ends coincide with the ends of one of the diagrams, and the crank angle corresponding to the given pressure rise is then read off. The time interval equivalent to this angle is readily found, and the corresponding mixture strength is obtained from the curves, Fig. 5.

The variations in strength of successive charges can be determined with ease in this way, and the average of such values agrees closely with the measured mean strength for the test. The usual variation corresponds to a fluctuation of about 25 per cent. in the air supplied per lb. of petrol. Values given by such curves as the above can probably only be considered in relation to the particular engine used in the determination of the curves themselves, but apart from the use of a single

cylinder only the engine now in question can be taken as being fairly typical of modern practice.

DISCUSSION.

Mr. A. T. J. Kearsey, in opening the discussion, said the paper gave rise to rather important questions. Firstly, could the diagrams be relied on as true records of what happened in the cylinder? Secondly, the value of the method of estimating the changes in the air-petrol rates for consecutive charges was extremely important. In his own experience with the Dalby-Watson indicator he had found that the gauges were liable to cause pre-ignition, and he thought that the author's method of overcoming gas oscillations with a bent tail pipe might distort the diagram. He referred to the paper by Mr. Wood and Professor Morgan in 1923, and mentioned that, with a long tube of small bore, these investigators had found a difference in calibration with the pipe at different temperatures. They had also found the calibration to vary with the speed. Mr. Kearsey mentioned that he had had trouble with the pressure-mirror suspension, the phase gear drive, and with the vibration of the engine being imparted to the indicator, but he thought that the most serious troubles with indicators of this type were local heating of the diaphragm and hysteresis due to clamping. He doubted whether Mr. Baker would be able to get anything very satisfactory in the way of acceleration diagrams, as the conditions on starting up an engine were different from those existing on full throttle and fixed ignition, and were such as might not be shown by the indicator. In conclusion, he asked for the author's opinion as to the reason for the variations of successive diagrams. Was this due to a variation in the actual quantity of mixture getting into the cylinder or the quality of the mixture?

Mr. T. Bevan, in commenting on Fig. 5, said that all the curves showed a minimum time of expansion for a pressure rise of 200 lbs. per square inch with an air-petrol ratio of about 13. That corresponded to about 11–12 per cent. excess of petrol in the mixture, and corresponded to a mixture strength which would give maximum power from the engine and not maximum thermal efficiency. In regard to the shape of the curves, he wondered what was the cause of the difference in the time experienced for the explosion at the different speeds with the same air-petrol ratio. Apparently, that must be due to a difference in the turbulence, being greater at the higher speeds than at the lower speeds, because the pressure at the time the spark passed would be lower at the higher speeds than at the lower speeds, and therefore the rate of propagation of the flame would be lower for the higher speeds than the lower speeds. The two seemed to be working in opposite directions. The effect of turbulence must be very much in excess of that due to the pressure, in order to account for the decrease in the time of explosion in any one air-petrol ratio and at the different speeds.

Mr. Cussons said that, with regard to the tail pipe, he found that a bent tube was used in the case of the indicator employed by Mr. Watson many years ago in the Rolls-Royce works. One advantage of such a pipe was that it tended to isolate the indicator from the engine in respect of vibrations. He added that it was interesting to motor the engine round and observe the type of diagram with the ignition switch open.

Dr. T. B. Morley said that the remarks of the last speaker had made him think it might be of some interest to mention that the bent tail-pipe connection was at least twenty years old.

Mr. Mohn asked what was the object of the nickel gauze that was put in the indicator originally. He also asked how they calibrated those instruments.

Mr. H. H. Winstanley asked Mr. Baker if he had compared the indicated horse-power obtained from the card with that obtained by cutting out successive cylinders.

Professor G. G. Stoney said that he was not an internal-combustion engine man at all, but he had had considerable experience of high-speed work, and knew the difficulties of getting records of any sort in that work. There was one thing, of course, that he thought all investigators should try to prove, which was that the indicator was a true record of the pressures inside the cylinder. He understood that the oscillations were due to the diaphragm. He wondered whether anything could be done in the way of providing a diaphragm with critical damping, so as to avoid the oscillations, and thus get a truer diagram.

Mr. H. Wright Baker, in reply, said that with regard to the internal spring difficulty on the indicators, he had had difficulty with that in connection with the Midgley indicator. In connection with the heating of the diaphragm he thought they were fairly safe not to overheat the diaphragm if they cut down the space in the diaphragm chamber beneath the diaphragm itself. In a paper by Dr. Moss, an experiment was described in which a thermo-couple was put on to the centre of the diaphragm, and the temperature went up, after sprinkling with water, to 200 deg. C. He did not know the size of that diaphragm chamber, but he thought it might be larger than the one which he himself had been using. The temperature effect there was quite small. In connection with the heating of the nickel gauzes, he had had a very similar experience; he had found that the gauzes were overheating. The question of the accuracy of the diagrams was one of interest. That had been dealt with in a paper by Mr. Southern in the last proceedings in the comparison of the optical indicator, which he had evolved, with the R.A.E. electrical indicator. He had connected those two up on the same engine at the same time, and had obtained very close agreement between the two. It was quite possible that they were both in error, but the speaker rather doubted that, because the two were of quite different types. The question of the distortion of the diagram due to the tail pipe was one which he was not at all happy about at the moment. There was distortion somehow or other. The top portion of the diagrams was considerably greater than it should be, and he had not been able to find out why. There was a long pressure surge, and he could not be sure how that originated.

That might be the factor which was spoiling the top of his diagrams at present, but he was not sure. In relation to the reciprocating drive, there was a slight amount of slackness in the gears, but not nearly sufficient to correspond to the errors, which he thought were almost entirely due to the small pins in the reciprocating motion. It was very interesting to see that Dr. Moss and Mr. Southern had had some trouble in the same way, and seemed to agree that the small reciprocating motions were not reliable owing to slackness in the pin. Mr. Baker thought that all of them had agreed to adopt a very much larger scale for the reciprocating motion, and reduce it down afterwards. The effect of engine vibration on the indicator, on the mirror and the camera, was quite serious, but he was very fortunate in that his engine was bolted down to a heavy concrete foundation, and alongside that cylinder he had a round table and the indicator was mounted on that, so that the indicator had very little chance of vibrating. It did vibrate, however, and so did the engine, and that might be another cause of the long period vibration. The hysteresis due to clamping was a matter which he had not investigated very thoroughly. He would certainly be inclined to adopt the flat diaphragm, and do away entirely with any form of soft packing between the diaphragm and its clamps. He did not entirely agree with Mr. Kearsey's suggestion that he was going to have great difficulty in the acceleration test. He had got curves out which showed variations with air-petrol ratios. If he could correlate all his curves, he might be able to obtain some result. In relation to the variation in the explosion curve, the variation depended, possibly, both on quality and quantity. He had taken a number of spring curves and those grew very considerably. He did not think it was a variation in the quantity, but in the quality, of the mixture. The curves which he had shown he had taken to apply strictly to the engine on which the tests were made. He did not think they could generalise too much. There were so many unknown quantities—for instance the surge of the petrol in the pipe itself might be different on different engines. He thought that answered Mr. Bevan's question as well.

There was a question about Fig. 5. The curves in this figure all showed minima with an air-petrol ratio of about 13. It varied with the speed, and they had obtained maximum brake horse-power at different air-petrol ratios dependent on speed. At about 1,900 r.p.m. it came out just over 12, and at 1,000 r.p.m. it was just about 13. Those curves showed minima at just about the same points. It was interesting to test various connecting pipes. On one occasion he had been working with a very thin pipe, 1¼ in. in length, and obtaining big oscillations, but had happened to hit the top of the pipe on one side with a spanner. The effect of this had been to reduce the oscillations to about one-quarter of their previous value, apparently as a result of the bend in the pipe. On the actual engine he had an electric generator for absorbing the power. This was not nearly as satisfactory as an electrical dynamometer for motoring, but he had been able to get friction tests in that way. Mr. Mohn had raised the question of the real use of the nickel gauze. Probably that had been put in to prevent the flame from the engine reaching the diaphragm, but he really did not know. The effect of the gauze, and of the small holes, on the oscillation of the diaphragm were negligible. The calibration o the instrument was done by compressed air against a standard pressure gauge. He tested the pressure gauge periodically, and the diaphragm was calibrated after every day's run. The testing of the mean-effective pressure by cutting out the cylinders could not be employed on a single-cylinder unit, and the only way of doing this was to make an approximation from motoring tests. He had an excess mean-effective pressure in the cylinder of apparently between 6 per cent. and 11 per cent. Judging from the work of Dr. Moss and Mr. Southern, that was very largely due to the increase in friction under full load conditions Professor Stoney had raised the question of the testing of the indicator. He could only refer again to the

Fig. 3A. TESTS WITH VARYING MIXTURE STRENGTH. MEAN VALUE CARDS.

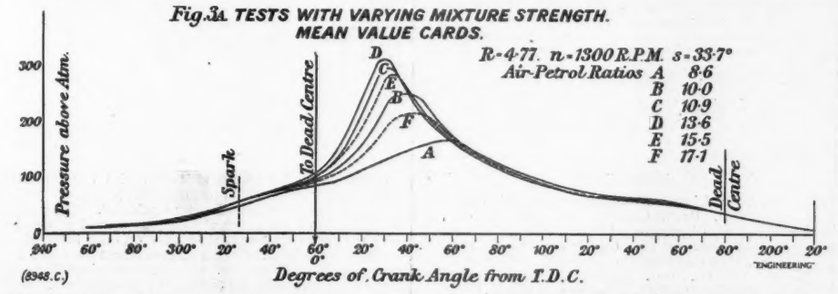


Fig. 3B. TESTS WITH VARYING MIXTURE STRENGTH. MEAN VALUE CARDS.

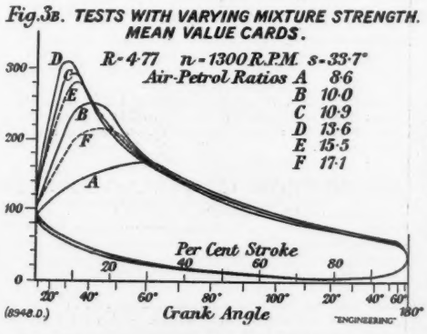


Fig. 4. PRESSURE RISE IN 0·007 SECOND FROM SPARK

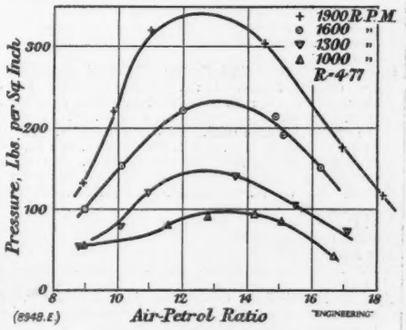
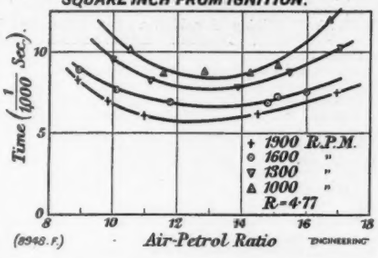


Fig. 5. TIME FOR INCREASE OF 200 LBS. PER SQUARE INCH FROM IGNITION.



testing against the electrical indicator of the R.A.E. pattern. That was moderately satisfactory. He did not know of any work which had been done to attempt to damp the oscillations.

LETTERS TO THE EDITOR.

HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

To the Editor of Engineering.

Sir,—I should esteem it a favour if, in connection with the very interesting article on the "Hydro-Electric Plant at Forshuvudforsen," a point arising out of the tests could be explained. In Fig. 101, page 217, of your last issue, are given results of measurements of pressures in the draught tube at different velocities of flow. As I am at present doing some experiments on bent draught tubes, I was interested in working out the efficiency of regain of this tube from the given results. I find, however, that with discharges between 30 m.³/s and 50 m.³/s the efficiency is apparently much greater than unity—as much as 3·26 at 30 m/s.—as indicated in the following table, in which v_1 is the velocity at entrance.

Q m³/s	30	40	50	60
v_1 m/s	2·13	2·91	3·64	4·36
$\frac{V_1^2}{2g}$ .. .. .. m.	0·242	0·432	0·675	0·968
Regain of head in draught tube m.	0·79	0·84	0·79	0·61
Efficiency of regain..	326 %	195 %	117 %	63 %

As the efficiency of regain of bent tubes is known to be somewhat low—probably not exceeding 60 per cent. in any case—it would be of interest if any explanati n could be afforded as to the reason for these apparently anomalous results.

Yours faithfully,
A. H. Gibson.

The University of Manchester, February 24, 1925.

MISSING PRESSURE AND HEAT LOSS IN GAS ENGINES.

To the Editor of Engineering.

Sir,—I have noted Professor David's reply of the 8th inst. to my letter of the previous week, and must thank him for his courteous acknowledgment of the communication I made.

To the writer's mind, the fact that a piece of paper was uncharred by the explosions in Professor David's experiments provides no conclusive evidence of the temperature to which the paper surface is momentarily subjected. The effect on the paper will depend, amongst other factors, upon the thickness of the paper, the backing or lack of backing with which it may be provided, and also on the chemical nature of the "atmosphere" with which it may be surrounded at the moment of maximum temperature.

Yours truly,
Wm. J. Walker.

University College, Dundee. February 18, 1925.

ANTI-FRICTION BEARINGS FOR HEAVY DUTY.

To the Editor of Engineering.

Sir,—I notice in your issue of the 13th inst. that a condensed report is given of some remarks that I made at the Meeting of the Institution of Mechanical Engineers on the evening of the 6th inst., when Mr. Dahlerus read his paper on "Anti-Friction Bearing Applications for Heavy Duty." In the process of condensation, I am afraid, my point has become obscured.

Mr. Pendred had raised a question about the causes of "dry erosion," and I offered as an explanation that the flow of metal on the surfaces, as these were ordinarily finished, would quite account for the cases that he quoted. I said that there was always a small flow of metal produced as the bearing surface was finished, and, in the ordinary types of bearings, this flow was not only considerable but was generally increased by use. On the other hand, in early roller and ball bearings, where the degree of accuracy although high was not nearly so high as at present (often to $\frac{1}{40,000}$) there was a risk of a destruction of the original polished surface by the alteration of surface stress and by vibration due to the less perfect mechanical fits. The micro-structure of metal shows that it is made up of grains of differing electrical potential, whilst Beilby has shown in his beautiful illustrations that burnishing or polishing masks this structure by a layer of more or less uniform "flow material," and this will have one potential only.

The destruction of the polished surface will at once expose the underlying grains of differing potential to the action of moist carbonic acid and oxygen and start corrosion, and even though the exposed surfaces be apparently dry and hot, the corrosion will end in erosion under the conditions named above.

Yours faithfully,
Henry C. Jenkins.

Salisbury House, E.C.2.
February 23, 1925.

BOOKS RECEIVED.

United States Bureau of Mines. Bulletin No. 228. *Estimation of Underground Oil Reserves by Oil-Well Production Curves.* By W. W. Cutter, Jr. [Price 20 cents.] Miners' Circular No. 28. *Sanitation in Mines.* By R. R. Sayers. [Price 5 cents.] Technical Paper No. 336. *Oxidation of Zinc Vapour by Carbon Dioxide.* By B. M. O'Harra. [Price 5 cents.] Washington: Government Printing Office.

Hydromechanik. By M. Samter. Charlottenburg: Robert Kiepert. [Price 3·20 marks.]

The Economics of Road Transport. By R. G. Fenelon, M.A. London: George Allen and Unwin, Limited. [Price 10*s.* 6*d.* net.]

The Price of Books. By Stanley Unwin. London: George Allen and Unwin, Limited. [Price 6*d.* net.]

Conformal Representation. By Leo Lewent. Translated by R. Jones, M.A., D.Sc., and D. H. Williams, B.Sc. London: Methuen and Co., Limited. [Price 7*s.* 6*d.* net.]

Das technische Eisen. Konstitution und Eigenschaften. by Dr. Ing. Paul Oberhoffer. Second edition. Berlin: Julius Springer. [Price 31·50 gold marks.]

Forschungsarbeiten auf dem Gebiete des Ingenieurwesens. No. 268. *Das Ziehen Unregelmässig-Geformter Hohlkorper.* By Dr. Ing. Hans D. Brasch. Berlin: V. D. I. Verlag, G.M.B.H. [Price 10 marks.]

Les Notions Fondamentales D'Element Chimique et D'Atome. By Georges Urbain. Paris: Gauthier-Villars et Cie. [Price 10 fr.]

Engineering Mathematics. By R. W. M. Gibbs, B.A., B.Sc. London: Blackie and Son, Limited. [Price 4*s.* net.]

United States Geological Survey. Mineral Resources of the United States. II: 9. *Clay in* 1923. By J. Middleton. II: 10. *Barytes and Barium Products in* 1923. By C. E. Siebenthal and E. R. Phillips. II: 12. *Graphite in* 1923. By J. Middleton. II: 13. *Fuller's Earth in* 1923. By J. Middleton. II: 15. *Salt, Bromine and Calcium Chloride in* 1923. By K. W. Cottrell. II: 16. *Asphalt and Related Bitumens in* 1923. By K. W. Cottrell. II: 17. *Mica in* 1923. By B. H. Stoddard. II: 23. *Coal in* 1922. By F. G. Tryon and S. A. Hale. Washington: Government Printing Office.

The Dust Hazard in Industry. By William E. Gibbs, D.Sc. London: Ernest Benn, Limited. [Price 6*s.* net.]

Agitating, Stirring, and Kneading Machinery. By Hartland Seymour. London: Ernest Benn, Limited. [Price 6*s.* net.]

Acid-Resisting Metals. By Sydney J. Tungay, M.I.Chem.E. London: Ernest Benn, Limited. [Price 6*s.* net.]

Mechanical Mixing Machinery. By Leonard Carpenter, B.Sc. London: Ernest Benn, Limited. [Price 6*s.* net.]

Distillation Principles. By C. Elliott, B.Sc. London: Ernest Benn, Limited. [Price 6*s.* net.]

University of Illinois. Engineering Experiment Station. Bulletin No. 143. *Tests on the Hydraulics and Pneumatics of House Plumbing.* By Harold C. Babbitt. Urbana: University of Illinois. [Price 40 cents.]

Die Kondensation bei Dampfkraftmaschinen. By Dr. Ing. K. Hoefer. Berlin: Julius Springer. [Price 22·50 gold marks.]

Rice. Its Cultivation and Preparation. By Charles E. Douglas, M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. [Price 3*s.* net.]

The Hodsock Ballistic Tables for Rifles. By F. W. Jones. *And an Appendix on the Ballistic Pendulum.* By Col. Lord Cottesloe, V.D. London: Edward Arnold and Co. [Price 10*s.* 6*d.* net.]

Memoirs of the Geological Survey. Special Reports on the Mineral Resources of Great Britain. Vol. VIII. *Iron Ores.—Hæmatites of West Cumberland, Lancashire, and the Lake District.* By Bernard Smith, M.A., Sc.D. Second edition. London: His Majesty's Stationery Office. [Price 5*s.* net.]

United States Coast and Geodetic Survey. Annual Report of the Director to the Secretary of Commerce, Year ended June 30, 1924. Washington: Government Printing Office. [Price 10 cents.]

The Institution of Aeronautical Engineers.—At a meeting of this Institution held on Friday last, the 20th instant, Professor E. G. Coker, F.R.S., gave a lecture and demonstration on "Photo-Elastic Methods of Measuring Stress." The general principles of the method were explained, the necessary apparatus described and the application of the system to practical problems, especially those relating to aircraft design, fully dealt with. The meeting was held in the lecture theatre of the Engineering Department of the University College, Gower-street, London, W.C.1, of which Department Professor Coker is the head.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—It is easier to point to signs of retrogression than of improvement in the steel and engineering industries. A strong effort is being made to maintain a spirit of quiet optimism, and, in support of the contention that things are not as bad as is represented in some quarters, the fact is stressed that, leaving armaments out of account, Sheffield's output is equal to the pre-war average, despite the circumstance that rates and taxes, labour costs, and international currencies are nearly all against fair competitive conditions. The difficulty that confronts the leading producers, however, is that most types of plant dealing with steel and machinery production, have been extended in greater measure than at any previous period in the industrial history of Sheffield and district. Thus, while to equal pre-war production in face of exceptionally trying factors is creditable to the expert organisation of representative works, it does not offer satisfactory compensation for the large amount of comparatively new plant standing wholly or periodically idle. Many more orders are wanted from export buyers before basic-steel furnaces can be operated profitably. The latest statistics reveal a tendency for acid-steel production to overtake that of mild steel. The explanation of this lies mainly in the class of material specified for the latest railway contracts. Crucible-steel manufacture is at a low ebb. On the other hand, there appears to be a growing demand for certain classes of constructional material and light castings. Ship steel has not improved as was anticipated. Many of the orders recently placed on British railway account have been worked off, but conditions are still fairly active in axles and springs. The patchy state of the tools trades is unaltered.

South Yorkshire Coal Trade.—Despite the fact that prices for export of steam fuel continue to sag, quotations for home deliveries are officially unaltered. The market is incapable of absorbing the current output of cobbles, with the result that special lots are on offer below listed rates. Slacks maintain the improvement recorded last week, while nuts are firmer. The promised improvement in house coal has not yet materialised. Both London and country buying is below normal. Cokes are weak but show no quotatable change. Quotations:—Best branch handpicked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 19*s.* 6*d.* to 23*s.*; Derbyshire hards, 19*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 9*s.* to 10*s.* 6*d.*; smalls, 4*s.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron makers declare that current rates barely cover working expenses, and that further fall in quotations would be speedily followed by more furnaces going out of operation. Customers at home and abroad, however, are not disposed to pay the figures named, and values are still on the downward curve. Transactions are on a very limited scale, Continental inquiries in particular being few and small. No. 1 is on sale at 83*s.* 6*d.*; No. 3 g.m.b. is offered at 78*s.* 6*d.*; No. 4 foundry is easy at 77*s.* 6*d.*; and No. 4 forge is no more than 76*s.* 6*d.*

Hematite.—Though East-Coast hematite producers are hampered by rather heavy unsold stocks, which are apparently not being reduced, they continue to endeavour to take a firm stand, and are very reluctant to reduce quotations. Home and Continental business is quiet, but hope is still entertained that fairly good sales to America may be recorded in the near future. Customers declare that they are able to obtain price concessions when they have definite proposals to make. Nos. 1, 2 and 3 are 85*s.* 6*d.*, and No. 1 is quoted 6*d.* above mixed numbers.

Foreign Ore.—Sales of foreign ore are almost unheard of. Sellers base market rates on best rubio at 22*s.* 6*d.* c.i.f. Tees, but would doubtless readily give favourable consideration to offers on lower terms.

Manufactured Iron and Steel.—Manufactured iron producers have moderate order books, but report that sales are slow. The demand for semi-finished steel is quiet, and finished steel materials are in poor request. Among the principal market quotations are:—Common iron bars, 12*l.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* 5*s.*; steel angles, 9*l.*; heavy sections of steel rails, 9*l.* 5*s.* to 9*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 17*l.*

Contracts.—The Associated Portland Cement Manufacturers have placed an order with Messrs. Vickers, Limited, of Barrow-in-Furness, for three kiln shells, each 250 ft. long, for service at Bevan's Works. Messrs. Vickers will also supply the condensing plant to be installed in connection with the new 6,000 kw. turbo-generator set ordered by the Brighton Corporation.—A contract for three 15,000-lb. cross-type water-tube boilers has been received from the Anglo-Scottish Beet Sugar Corporation by the Vickers-Spearing Boiler Company, Limited.—Howden-Ljungström Preheaters (Land), Limited, of Caxton House, London, S.W.1, have secured an order for one large preheater from Messrs. Chance and Hunt, Limited, chemical manufacturers, of Oldbury, near Birmingham.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—While the actual conditions in the Scottish steel trade have not in any way improved during the week, the announcement of one or two new shipbuilding contracts has sent forth another ray of hope. If the material required for these vessels is placed locally the steel industry will get a little benefit, and it is to be hoped that such will be the case as general trade in the district will also benefit. Fresh orders are still exceedingly scarce all round, and even specifications against contracts in hand are very difficult to secure. Few export lines are being picked up, and any on offer are subject to very low offers from Continental sellers. In the black sheet trade, old contracts are being run off at high pressure, but fresh orders to take their places are not just so plentiful this week. Quite a fair amount of work is assured nevertheless for some months ahead, particularly for the galvanised varieties for export. Prices all round show no change, and are quoted as under:—Boiler plates 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, $\frac{1}{16}$ in. to $\frac{1}{4}$ in., 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—There has been no change in the state of the West of Scotland malleable iron trade over the week. Buyers are few in number and orders are mostly for small lots for immediate requirements. The prospects are not very encouraging. In the steel re-rolling branches, the conditions, while better, are perhaps not quite so good as they were recently, and the competition to secure fresh orders is very keen. The price for "Crown" bars is unchanged at 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—The inquiry for Scottish pig-iron has not been very heavy this week, and even the demand for lots against contract is almost negligible. The outlook overall is not encouraging and unless there is some change for the better very soon and stocks become sensibly reduced, a further curtailment in output may take place. Prices are just barely steady and may be taken as follows:—Hematite, 4*l.* 12*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 11*s.* 6*d.* per ton, and No. 3, 4*l.* 9*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour during the week ending last Saturday, February 21, was rather better than during recent weeks and amounted to 1,731 tons. Of that total, 1,610 tons went overseas and 121 tons coastwise. For the corresponding week of last year the figures were 175 tons to foreign ports and 92 tons coastwise, making a total shipment of 267 tons.

Shipbuilding.—It is satisfactory to be able to state that Clyde shipbuilders have received orders for four new vessels. These are for Messrs. H. Hogarth & Sons, Glasgow, proprietors of the Baron Line of steamers. Messrs. Lithgows, Limited, Port Glasgow, are to build two of the vessels, and for these the triple expansion engines will be supplied by Messrs. John G. Kincaid and Co., Limited, Greenock. The other firms who have each received an order for one steamer are Messrs. Napier and Miller, Limited, Old Kilpatrick, and the Ayrshire Dockyard Company, Limited, Irvine. The engines for these two steamers are to be supplied by Messrs. David Rowan and Co., Glasgow. All the four vessels will have a deadweight carrying capacity of 5,500 tons and will be 336 ft. long and 48 ft. 6 in. beam.

PRESSURE TEMPERATURE CHARTS.—We have received from the Contraflo Engineering Company, Limited, of 3, Central Buildings, Westminster, a celluloid card having engraved on the one side scales showing the temperature corresponding to different vacua expressed in inches of mercury, and on the other similar scales indicating the steam pressure corresponding to different temperatures. The card being, as stated, of celluloid can be carried in the pocket without risk of being damaged, and will no doubt prove a convenience to many. It is being sold at the price of 2*s.* 6*d.* net.

SMALL TOOLS FOR MACHINISTS: ADDENDUM.—We regret that, by an oversight, we omitted to mention that the particulars of the Brown and Sharpe small tools for machinists, illustrated and described in our last issue, on page 241, were supplied to us by Messrs. Buck and Hickman, Limited, 2, 4 and 6, Whitechapel-road, London, E.1. Messrs. Buck and Hickman, as is well-known, are joint agents in this country for all kinds of Brown and Sharpe small tools, and are also sole agents for the milling machines, grinding machines, screw machines, and gear-cutting machines, made by the Brown and Sharpe Manufacturing Company

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THE WIRELESS TELEGRAPHY AND SIGNALLING BILL.—We are informed that the Council of the Institution of Electrical Engineers, being of the opinion that there are provisions in the new Wireless Telegraphy and Signalling Bill, which are likely to prove detrimental to the progress of wireless telegraphy, of radio science generally, and of other electrical matters, have addressed a letter to the Postmaster-General asking him to defer any immediate further proceedings with the Bill. In the letter, which was dated February 19, 1925, the Council pointed out that the provisions of the new Bill, which had only been published a few days before the date of the letter, were of far-reaching importance and they wished for time to give careful consideration to the proposals and for an opportunity of submitting to the Postmaster-General their representations on the subject.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night, at 7 p.m., at Storey's Gate, S.W.1. Informal Meeting. Discussion on "Practical Problems of Lubrication." Monday, March 2, at 7 p.m. Graduates' Section. Annual Lecture. "A Visit to America," by Mr. William H. Patchell.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night, at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette, "A Treatise on Modern Lighting Practice," by Mr. E. Stroud. Friday, March 6, at 7.30 p.m., Lecturette, "How to Apply for a Job and how not to do it," by Mr. E. Fiander Etchells.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—To-night, at 7.30 p.m., at Watergate House, Adelphi, W.C.2. London Graduates' Meeting, "Why Pneumatic Tyres?" by Mr. R. Marks.

THE HULL ASSOCIATION OF ENGINEERS.—Saturday, February 28, at 7.15 p.m., at the Hull Technical College. Lecture, "Road Passenger Transport," by Mr. E. S. Rayner, M.I.E.E.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Monday, March 2, at 5 p.m., at Albemarle-street, W.1. General Meeting, Saturday, March 7, at 3 p.m., "The Counting of the Atoms" (Lecture II), by Sir Ernest Rutherford.

THE INSTITUTE OF TRANSPORT.—Monday, March 2, at 5.30 p.m., at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, "The Manipulation of Exceptional Passenger Traffics," by Mr. E. C. Cox.

THE SOCIETY OF ENGINEERS.—Monday, March 2, at 5.30 p.m., at the Geological Society, Burlington House, Piccadilly, W.1, "Notes on Preparing a Tender," by Mr. R. I. Money, M.Inst.C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WESTERN CENTRE.—Monday, March 2, at 6 p.m., at the South Wales Institute of Engineers, Park Place, Cardiff, "The Drive of Power Station Auxiliaries," by Mr. L. Breach and Mr. H. Midgley.

THE BRADFORD ENGINEERING SOCIETY.—Monday, March 2, at 7.30 p.m., at the Technical College, Great Horton-road, Bradford. Lecture, "Modern Developments in Power Generation," by Mr. J. Townley.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, March 2, at 7.30 p.m., in the Lecture Theatre, Mining Institute, Neville Hall, Newcastle-upon-Tyne, "Construction of the Burnhope Intake and Pipe Line and also the Stanhope Tunnel for the Durham County Water Board," by Mr. H. Robinson, M.Inst.C.E.

THE ROYAL SOCIETY OF ARTS.—Monday, March 2, at 8 p.m., at John-street, Adelphi, W.C.2. Cantor Lectures, "The Inner Structure of Alloys" (Lecture III), by Dr. Walter Rosenhain, F.R.S. Wednesday, March 4, at 8 p.m. Ordinary Meeting, "The Modern Production of Sheet-Glass," by Professor W. E. S. Turner, D.Sc. Friday, March 6, at 4.30 p.m., Indian Section, "The Development of Indian Universities," by Sir Henry Sharp, C.S.I., M.A.

THE INSTITUTION OF RUBBER INDUSTRY.—Monday, March 2, at 8 p.m., at the Engineers' Club, Coventry-street, W.1, "Modern Materials used in Rubber Compounding," by Dr. A. A. Somerville.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, March 3, at 6.30 p.m., at 85-88, The Minories, Tower Hill, E.1, "Fuel Economy," by Mr. E. W. L. Nicol.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, March 3, at 7 p.m., at the Chamber of Commerce, New-street, Birmingham, "Slags and Fluxes: their Composition and Uses," by Mr. J. H. Russell.

THE WEST YORKSHIRE METALLURGICAL SOCIETY.—Tuesday, March 3, at 7.30 p.m., at the George Hotel, Huddersfield. Discussion on "The Connection between the Microstructure and Mechanical Properties of Metals and Alloys."

THE SOCIETY OF CHEMICAL INDUSTRY.—Tuesday, March 3, at the Hull Photographic Society, Grey Street, Hull, Joint Meeting with the Chemical and Engineering Group and the Hull Chemical and Engineering Society. "Pneumatic Transport," by Dr. William Cramp, M.I.E.E.

THE NEWCOMEN SOCIETY.—Wednesday, March 4, at 5.30 p.m., at Prince Henry's Room, 17, Fleet-street, E.C.4, "Gun Handicraft," by Mr. C. E. Greener.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Wireless Section Meeting, Wednesday, March 4, at 6 p.m., at Savoy Place, Victoria Embankment, W.C.2, "Current Transformer Methods of Producing Small Known Voltages and Currents at Radio Frequencies for Calibrating Purposes," by Mr. D. Dye, B.Sc. "The Measurement of Frequency and Allied Quantities in Wireless Telegraphy," by Lieut.-Col. K. E. Edgworth. Thursday, March 5, at 6 p.m., Ordinary Meeting, "The Post Office and Automatic Telephones," by Colonel T. F. Purves.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Wednesday, March 4, at 7 p.m., at the Engineers' Club, Coventry-street, W.1, "Water Softening in Relation to Heating and Domestic Hot Water Supply," by Mr. W. B. Lewis.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, March 4, at 8 p.m., at the Society's Rooms, The Temple, Dale-street, Liverpool, "Construction of a Spirally-Guided Gas Holder and Tank at Garston," by Mr. E. Astbury.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, March 5, at 5.30 p.m., at 7, Albemarle-street, W.1, "Some Medical Aspects of Air Transport," by Lieut.-Col. C. B. Heald.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS; EASTERN AND SOUTH MIDLAND DISTRICTS.—Saturday, March 7, at 2.35 p.m., at the Town Hall, Ealing, W.5, "Consider the Question of Regional Town Planning and, if possible, Initiate Regional Town Planning Committees for each District." Various visits.

THE SCIENTIFIC SOCIETY OF THE ROYAL TECHNICAL COLLEGE.—Saturday, March 7, at 7.30 p.m., at the Royal Technical College, George-street, Glasgow, "A Practical Method of Testing Large Motors and Generators," by Mr. Edward G. Tasker, M.I.E.E., M.I.Mech.E.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—New business remains on a limited scale with the demand insufficient to absorb available supplies, despite reduced outputs caused by frequent and numerous stoppages at the pits. The supply of shipping reaching port is also much below normal, which circumstance aggravates the difficulty of salesmen, who find it impossible to keep collieries working anything like regularly on account of a shortage of empty wagons. Best Admiralty large coals are readily obtainable at 26*s.* to 27*s.*, with seconds from 25*s.* to 25*s.* 6*d.* and Monmouthshires from 23*s.* to 24*s.* 6*d.*, while smalls ruled from 12*s.* to 16*s.*, according to quality, with the better sorts available at a concession of 6*d.* if taken in conjunction with large. The Great Southern Railway of Ireland, comprising four amalgamated lines and about 25 local lines, are inviting f.o.b. tenders for 120,000 tons of locomotive coal with delivery over the next six months, or 240,000 tons over the next twelve months. The French State Railways also want c.i.f. tenders for 10,000 tons of large coal, chiefly Monmouthshires, and 20,000 tons of small over the next three months. The inquiry of the Government for 5,000 tons of large for Jamaica has been withdrawn. Exports of coal as cargo from South Wales last week totalled 467,950 tons, compared with 456,190 tons in the previous week. Shipments of coal from South Wales in January amounted to 2,383,682 tons, of which 1,928,856 tons were despatched abroad as cargo, 334,699 tons as bunkers for foreign trading vessels, and 120,127 tons as cargo coastwise. Exports of patent fuel totalled 96,089 tons, and of coke 7,556 tons. Imports of pitwood amounted to 168,323 loads, and of iron ore to 151,349 tons.

Shipowners' Annual Report.—In the annual report of the Cardiff and Bristol Channel Shipowners' Association it is stated that, "taking the industry as a whole, it cannot be said that there was any distinct improvement but there were slight signs of better times to come. Although the number of vessels laid up was not reduced to moderate proportions, so many obsolete ships were broken up that a reduction was effected in the total of the world's tonnage for the first time since the war. Some progress was made during the year towards European commercial peace, and the value of the pound materially recovered, so that it should before long regain parity, helping to increase international commerce to the benefit of the sea carriers. The market for tonnage in 1924 showed a complete reversal in comparison with the conditions obtaining in 1923. In the former year the increase in coal exports and the resultant additional demand for coal-carrying tonnage was a saving feature at a time when imports had dropped to a low level. Contrarily, in 1924 coal freights were very low, but a scarcity of grain in Europe necessitated heavier import from Canada, the Plate and Australia, and homeward freights were more plentiful and improved. Expressions of opinion as to the future of the shipping industry are now generally more optimistic. British commerce has already shown slight improvement with the departure from power of the Labour Government, and the prospect of political tranquility. Foreign exchanges are becoming more stable and European commercial relations are steadily improving. International trade should increase, with a resultant greater demand for sea transport. Such expanded demand, coupled with a decrease in the supply of tonnage owing to the gradual withdrawal of obsolete vessels, should tend to remove the present depression in the shipping industry."

BRITISH INDIA LINER SANTHIA.—A successful trial trip was recently completed by the ss. Santhia, a passenger and cargo steamer constructed to the order of the British India Steam Navigation Co., Limited, of London, by Messrs. Swan, Hunter and Wigham Richardson, Limited, at their Neptune Works, Newcastle-on-Tyne. Built of steel, the vessel is 451 ft. in length, 57$\frac{1}{2}$ ft. in breadth, and has a moulded depth of 36$\frac{1}{4}$ ft. A deadweight of 9,500 tons can be carried on a draught of 27 ft. Triple-expansion engines drive twin-screws, which impart a speed of 14 knots to the ship. The auxiliary machinery includes a steam windlass, steam steering gear, and 12 steam winches, together with derricks, &c. Electric light is fitted throughout. Since the vessel is intended for trade in the tropics, the ventilation has been carefully designed on a generous scale. The lifeboats are made of steel. Steam-heating and refrigeration plant has been provided, together with the necessary insulated store rooms for the ships' provisions. Excellent accommodation is supplied for 24 first-class and 24 second-class passengers, while provision can be made for the carrying of 3,000 natives.

THE RECONSTRUCTION OF THE WATERLOO BRIDGE, BETTWS-Y-COED.

CONSTRUCTED BY MESSRS. L. G. MOUCHEL AND PARTNERS, LIMITED, ENGINEERS, WESTMINSTER.

(*For Description, see Page* 250.)

FIG. 2. VIEW OF BRIDGE BEFORE RECONSTRUCTION.

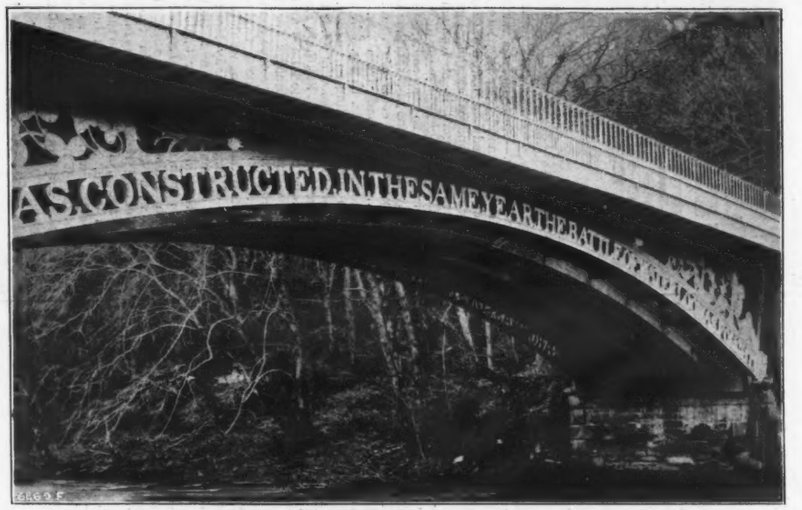


FIG. 4. VIEW OF BRIDGE AFTER WIDENING AND STRENGTHENING.

FIG. 3. VIEW OF ROADWAY BEFORE WIDENING.

FIG. 5. VIEW OF ROADWAY AS WIDENED.

CROSS OIL-CRACKING PLANT OF THE MEDWAY OIL AND STORAGE COMPANY, LIMITED.

(*For Description, see Page* 247.)

FIG. 5. STORAGE TANKS FOR PETROL, RECHARGING STOCK AND KEROSENE.

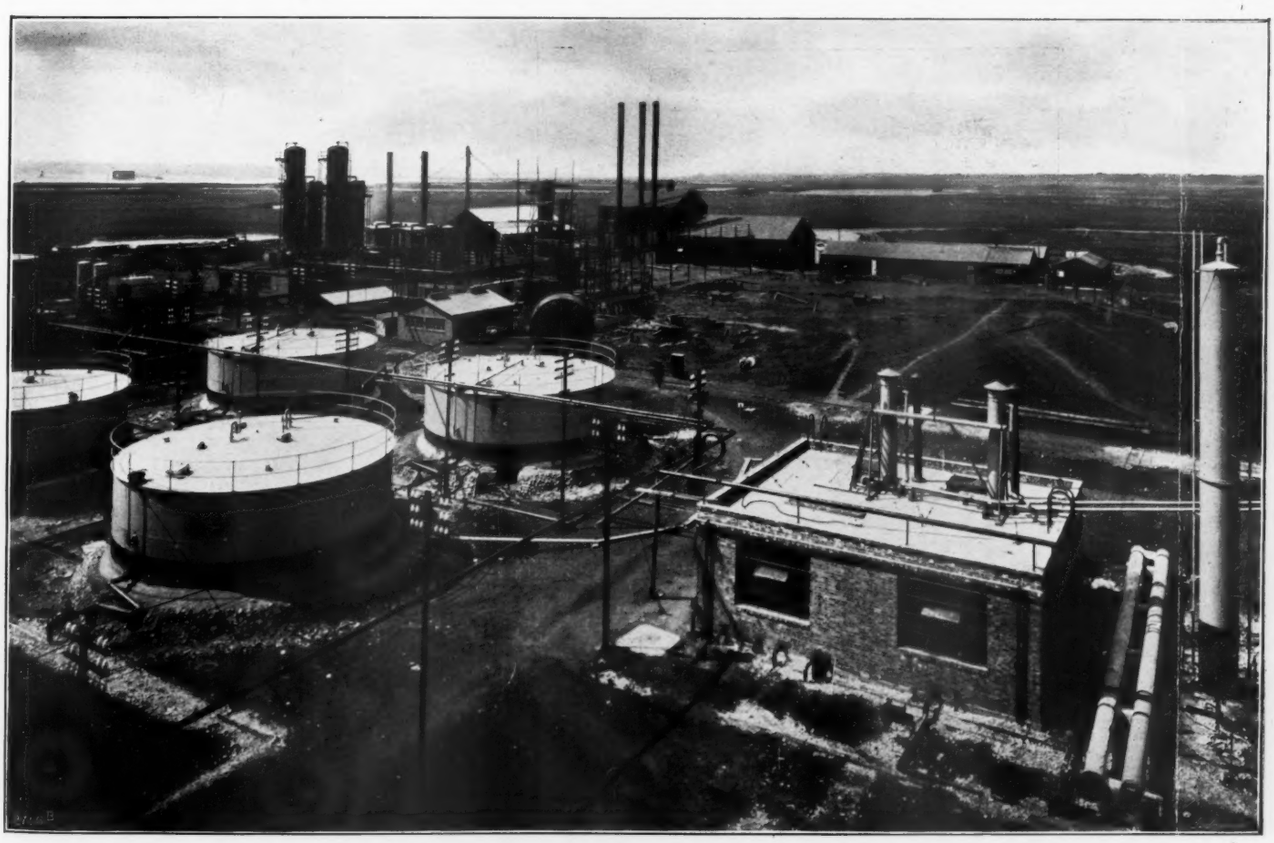


FIG. 6. PETROL TANKS AND BENWICK ABSORPTION PLANT.

(*To face page* 248.)

CROSS OIL-CRACKING PLANT OF THE MEDWAY OIL AND STORAGE COMPANY, LIMITED, ISLE OF GRAIN, KENT.

(*For Description, see Page 247.*)

FIG. 7. INTERIOR OF PUMP HOUSE AT PIER.

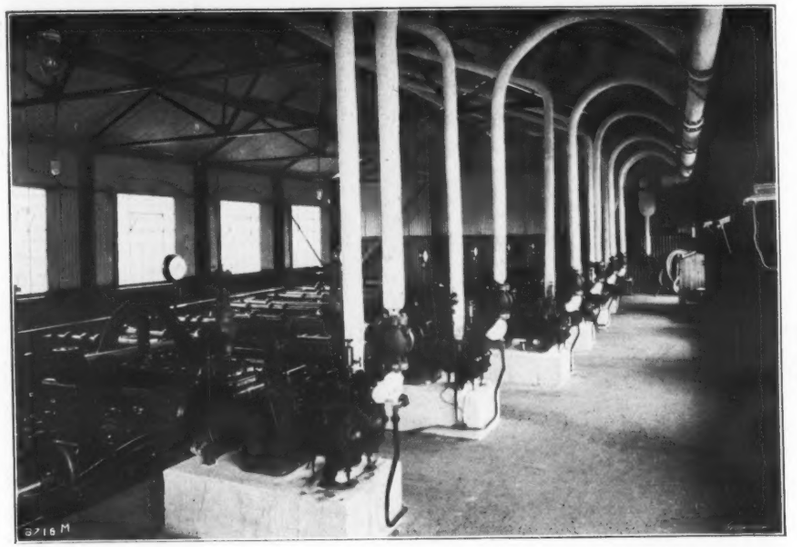
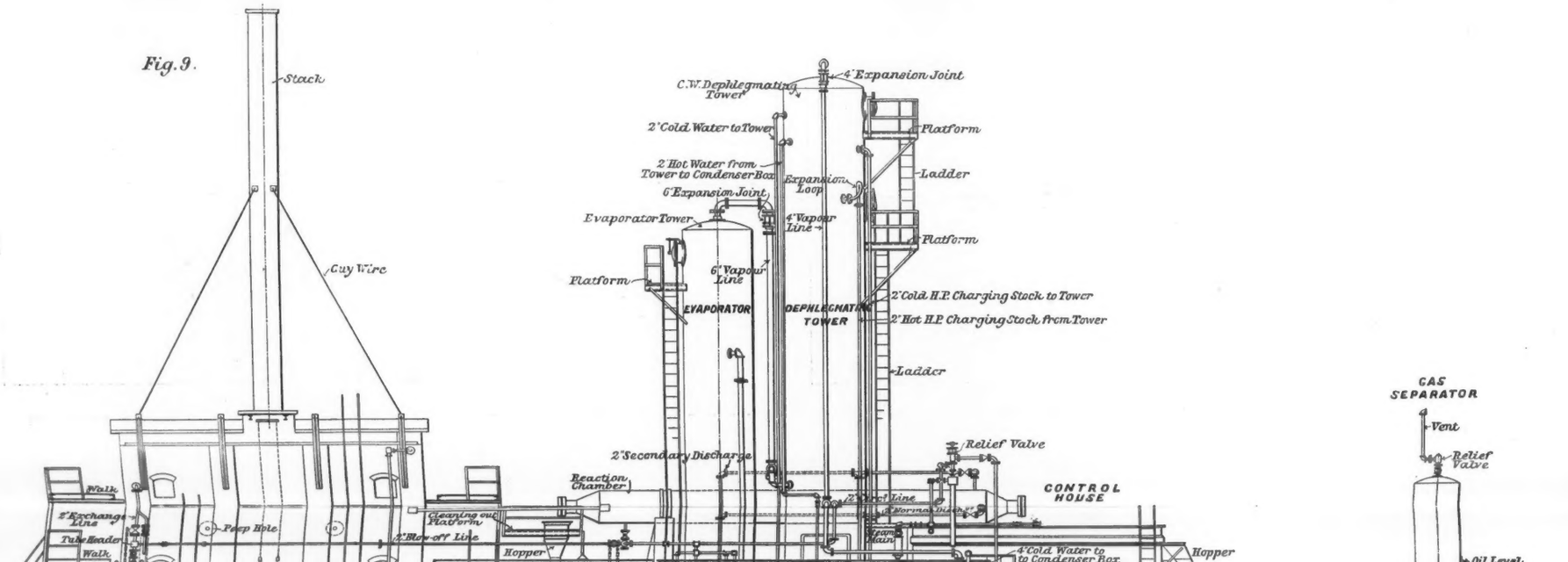


FIG. 8. INTERIOR OF PUMP HOUSE IN MAIN PLANT.

Fig. 9.



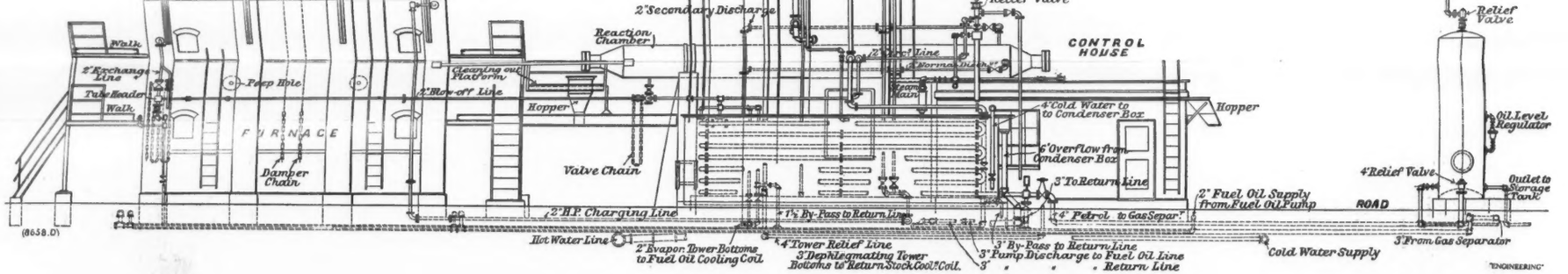
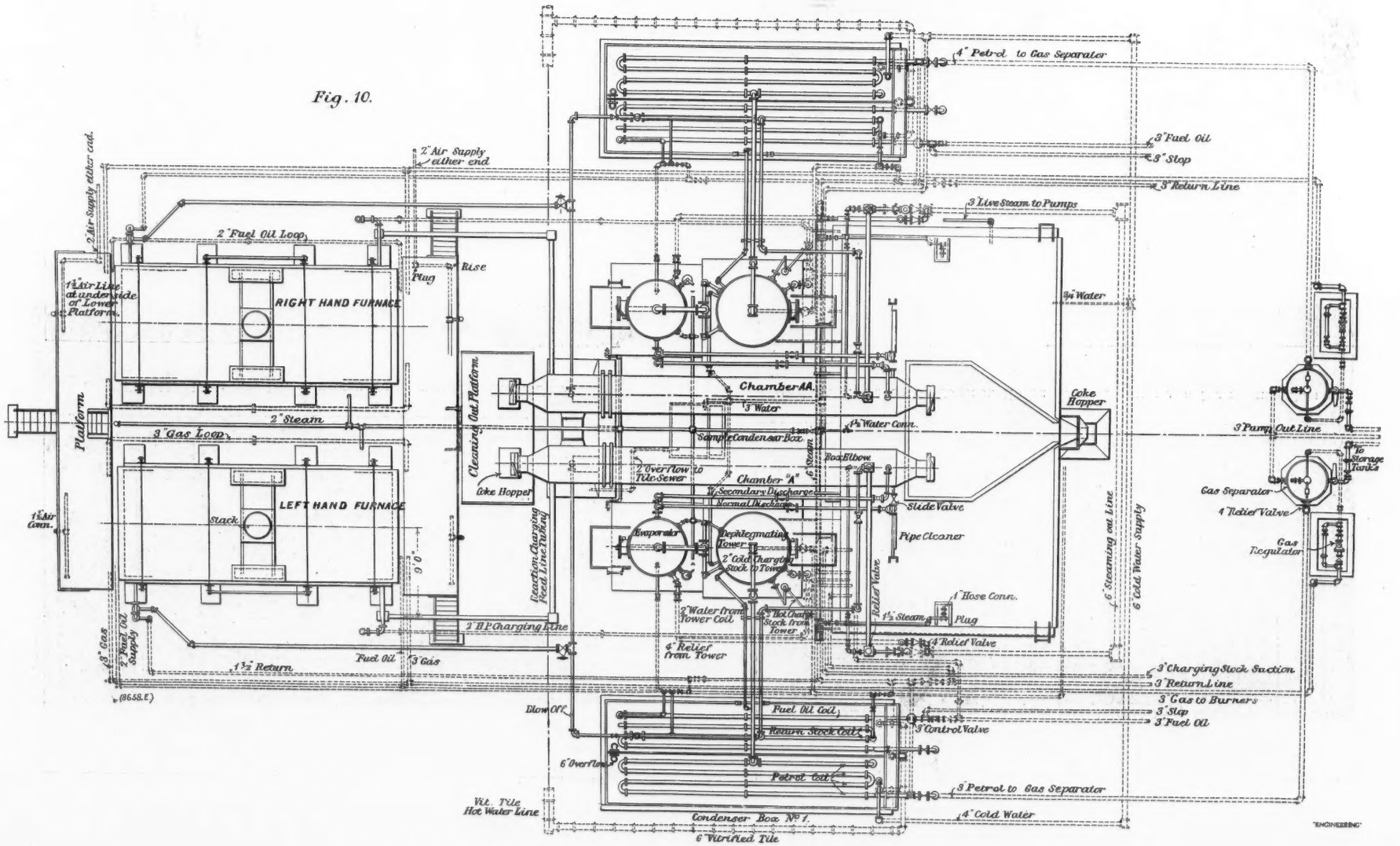

Walk
2" Exchange Line
Tube Feeder
Walk
Peep Hole
Clearing out Platform
2" Blow off Line
Hopper
FURNACE
Damper Chain
Valve Chain
Reaction Chamber
2" Secondary Discharge
CONTROL HOUSE
Hopper
4" Cold Water to to Condenser Box
6" Overflow from Condenser Box
3" To Return Line
2" Fuel Oil Supply from Fuel Oil Pump
ROAD
2" H.P. Charging Line
1½" By-Pass to Return Line
4" Petrol to Gas Separ.
Hot Water Line
2" Evapor. Tower Bottoms to Fuel Oil Cooling Coil
4" Tower Relief Line
3" Dephlegmating Tower Bottoms to Return Stock Cool.r Coil.
3" By-Pass to Return Line
3" Pump Discharge to Fuel Oil Line
Return Line
Cold Water Supply
Relief Valve
Oil Level Regulator
4" Relief Valve
Outlet to Storage Tank
3" From Gas Separator
(8658.D)
"ENGINEERING"

Fig. 10.


2" Air Supply either end
2" Air Supply other end
2" Fuel Oil Loop
Rise
Plug
1½" Air Line at underside of Lower Platform
RIGHT HAND FURNACE
Platform
2" Steam
3" Gas Loop
LEFT HAND FURNACE
Stack
1" Air Conn.
9'0"
Cleaning Out Platform
Coke Hopper
Reaction Charging Feed Line Trolley
2" H.P. Charging Line
3" Gas
2" Fuel Oil Supply
1½" Return
Fuel Oil
3" Gas
(8658.E)
4" Petrol to Gas Separator
3" Fuel Oil
3" Stop
3" Return Line
3" Live Steam to Pumps
¾" Water
Chamber AA
3" Water
Sample Condenser Box
1½" Water Conn.
6" Steam
Box Elbow
2" Overflow to Pit or Sewer
Chamber "A"
2" Secondary Discharge
Normal Discharge
Coke Hopper
Slide Valve
Pipe Cleaner
Evaporator
Dephlegmating Tower
2" Cold Charging Stock to Tower
Relief Valve
1" Hose Conn.
1½" Steam
Plug
2" Water from Tower Coil
2" Hot Charging Stock from Tower
4" Relief from Tower
4" Relief Valve
6" Steaming out Line
6" Cold Water Supply
3" Charging Stock Suction
3" Return Line
3" Gas to Burners
3" Stop
3" Fuel Oil
3" Control Valve
Blow Off
Fuel Oil Coil
Return Stock Coil
6" Overflow
Petrol Coil
3" Petrol to Gas Separator
4" Cold Water
Vit. Tile Hot Water Line
Condenser Box No 1.
6" Vitrified Tile
3" Pump Out Line
To Storage Tanks
Gas Separator
4" Relief Valve
Gas Regulator
"ENGINEERING"

CROSS OIL-CRACKING PLANT OF THE MEDWAY OIL AND STORAGE COMPANY, LIMITED.

(*For Description, see Page 247.*)

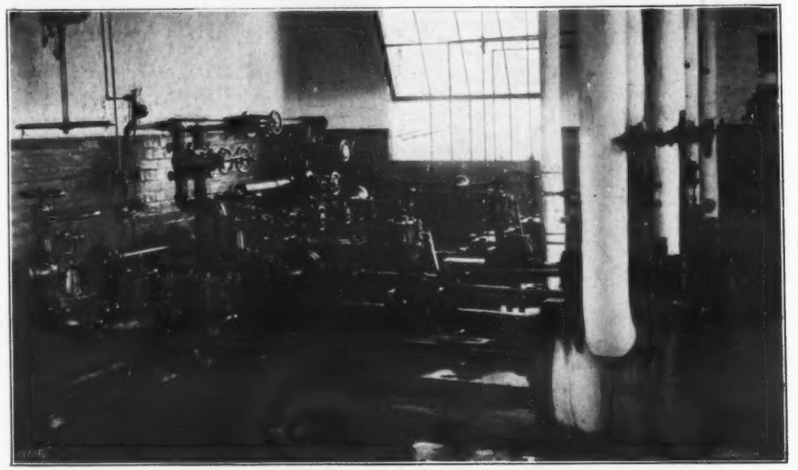


FIG. 11. HIGH AND LOW-PRESSURE PUMPS FOR ONE CROSS UNIT.

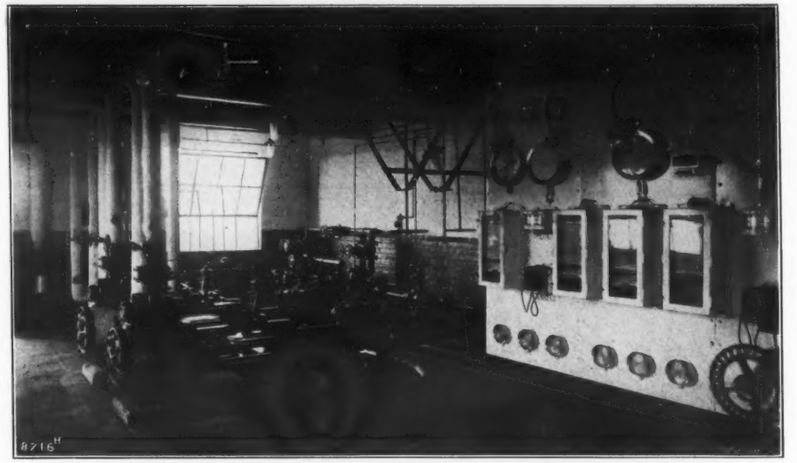


FIG. 12. INTERIOR OF CONTROL HOUSE SHOWING PUMPS AND INSTRUMENT BOARD.

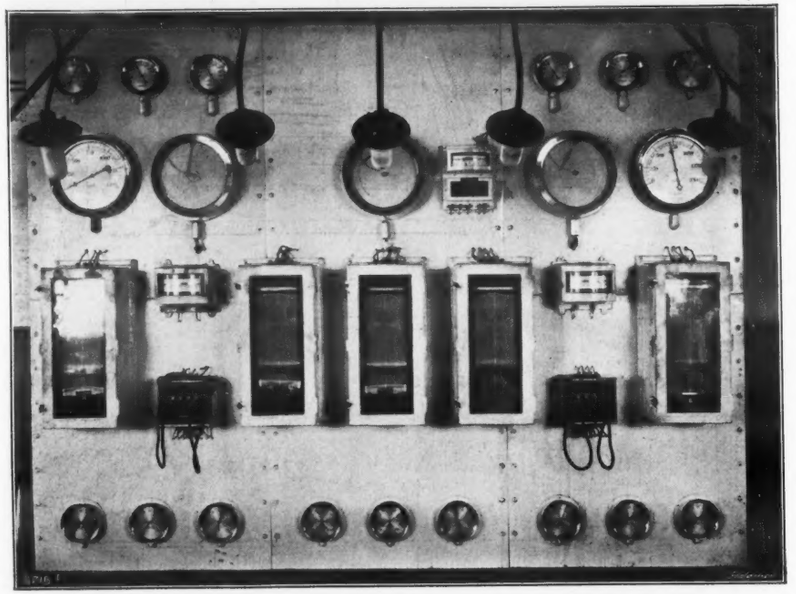


FIG. 13. MAIN INSTRUMENT BOARD FOR TWO CROSS UNITS.

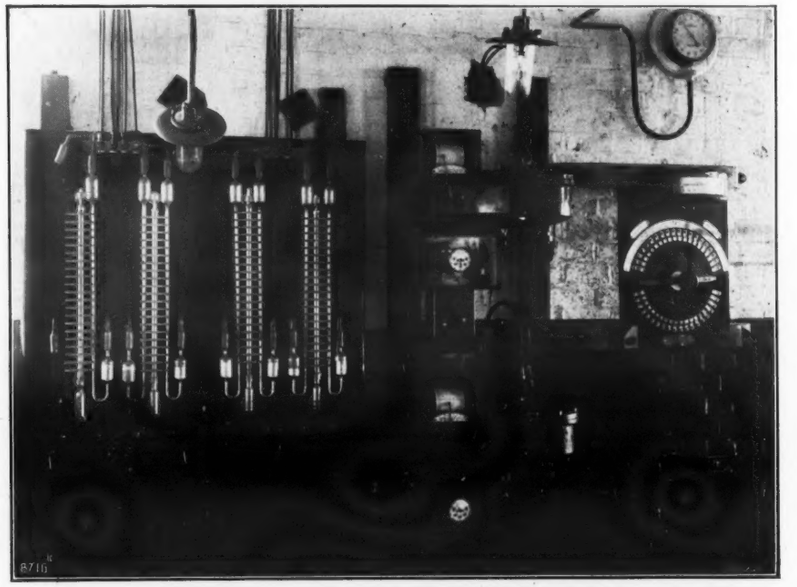


FIG. 14. MERCURY DEPTH GAUGES, GAS METER AND ELECTRICAL PYROMETER.

(*To face page 249.*)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand. London, W.C.2.

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One Two-Page Plate and Two One-Page Plates.—*CROSS OIL-CRACKING PLANT OF THE MEDWAY OIL AND STORAGE COMPANY, LIMITED.*

ENGINEERING.

FRIDAY, FEBRUARY 27, 1925.

WATERLOO BRIDGE.

ELSEWHERE in this issue we describe the successful scheme adopted under the auspices of the Ministry of Transport to bring the graceful Waterloo Bridge of Telford, at Bettws-y-Coed, into line with modern traffic requirements. It is a coincidence that in the same issue we should have occasion also to discuss the fate of the Waterloo Bridge over the Thames—Rennie's great masterpiece. On Tuesday last the London County Council decided, without division, that it was advisable to replace this work by a bridge of not more than five spans, wide enough to take six lines of traffic. The Council is, however, still willing to consider possible alternatives.

This question of the repair or demolition of this famous structure has recently been so hotly contested that we hesitate to enter the lists with the expression of views founded only upon official reports when so many others appear to have made exhaustive investigation of the state of the structure itself and of the river channels. Yet we feel that the reports we refer to contain well-reasoned arguments, and when the conclusions in them are known to have been reached only with the greatest reluctance, they deserve, in our opinion, the fullest consideration.

All must admit at the outset that the whole question is extraordinarily complicated by a concatenation of circumstances, each of which taken singly would suffice in any ordinary case either to perpetuate the bridge in its present form, or to condemn it out of hand. The controversy has not, however, been carried on altogether in the best spirit in the daily Press, and matters have been introduced which might well have been left alone.

There are no less than five distinctly conflicting sapects to be reconciled. First, we may place the archæological aspect, and next the town planner's point of view. There is then the engineer's standpoint, followed on a lower level by the more mercenary views of the ordinary businessman and the navigation interests. We are all ready to pay our homage to Rennie's work as one of the finest, if not *the* finest, bridge of its kind in existence. It is to the everlasting credit of our profession that the architects as a body should rally so strongly in the defence and preservation of this monumental work of an engineer. The view of this bridge, with London's other great masterpiece, St. Paul's, standing behind it, as seen from the Hungerford Bridge, is certainly one of the most beautiful to be found anywhere. It is one of very few redeeming features of the Hungerford Bridge that it enables thousands of Londoners to enjoy this panorama daily. We can well understand, therefore, the attitude of those who regard themselves as the special custodians of the all-too-few beauties of our cities, and we have every sympathy with the strenuous efforts to preserve without modification this great harmony set in our midst.

The town planners are not quite so easy to deal with. Usually these reformers call for wide spaces and imposing width—the abolition of bottle necks in arteries, and—not infrequently—are averse to any interference with their ideals due to conservative policy of any kind. In this instance, however, they would appear to be on the side of the most conservative of conservative professions, and progressive and serviceable plans are for once at least held up in the clash with considerations of beauty. As a compromise a second bridge is proposed on the Temple side of the present structure, but there are evident difficulties in the way of this.

The business aspect of the situation is simply that the present structure is inadequate and must be enlarged. With a bridge capable of taking, as proposed, six lines of traffic, and with the suggested subway at the Strand end, capable of passing in, at the reduced height contemplated, about 90 per cent. of the traffic offering, the traffic facilities would be greatly improved. This would be most welcome to all having to do with cartage problems in this central area. However, here we are met with two other difficulties, both the æsthetics and the navigators being opposed to the widening of the present bridge. The point of view of the navigation interests is frankly selfish, but we must admit that in such a port as London they must be allowed due weight in the conduct of affairs. Some years since, if we remember rightly, *Punch* pictured an astonished old rustic standing on a Tube station platform, with his equally astonished wife, and exclainimg, as one train after another disappeared into the tunnel, "Lor! Maria, look at that! Bang into the hole every time!"—or words to that effect. The same precision of movement is not at the command of the navigator of a Thames lighter, or of the skipper of a tow of barges, to say nothing of the larger vessels now habitually frequenting the reaches above Westminster Bridge. It is certainly not in the interest of these that the present eight spans should be preserved, much less that the arches should be converted into short tunnels by a material increase in the width of Rennie's bridge, as was once proposed. The suggested widening had few friends, since the present beauty of the structure depends on the proportion of the arches to width, and the general impression with altered proportions would not be nearly so favourable. For the navigator, undoubtedly, a bridge of five spans as now proposed would be greatly preferable.

We come last of all to the important engineering aspect of the case. Little is proposed in these days of publicity which does not provoke some opposition. In politics, either in the Press or in Parliament, opposite factions are continually deciding contentious points. In the profession doctors frequently disagree. In engineering it often happens that alternatives suggest themselves. It is therefore not surprising that expert opinion has been expressed in opposition to the demolition of the bridge. On the other hand, opinion no less expert has decided that the best course to pursue is to replace the present bridge by a completely new one. The London County Council has consulted experts of the very highest standing on this matter. Its

own engineer, a member of the Council of the Institution of Civil Engineers, reported on the case some time ago. Not satisfied with this, under the exceptional circumstances, the Council next called in Mr. Basil Mott and Sir Maurice Fitzmaurice. As both these engineers have had the honour of occupying the most eminent position at the bestowal of the profession it is difficult to see to whom application could have been made for a decision in which greater confidence might be placed. Nevertheless the London County Council sought still further guidance in the matter, hoping thereby to secure an opinion which would be admitted as final. Of this endeavour we need only say that we consider it to have been unfortunate. As we pointed out at the time, apart from points of professional etiquette it is clearly impossible for a mixed body such as the Council of the Institution of Civil Engineers, composed as it is of mechanical and electrical engineers, shipbuilders and others in addition to civil engineers, to give any useful opinion on a technical point relating to a special branch of the profession. In any case, it would have been hardly rational to anticipate any ruling at variance with the opinions previously given by two presidents and one of their members. The reply of the Council of the Institution perhaps unfortunately, did not stop at the acknowledgment of the courtesy implied in the request. Added to this was a phrase which has been the subject of some criticism. We do not believe, however, that that body ever wished to trespass on forbidden ground, and prefer to accept the second part of its letter more as a review of the situation than as a veiled expression of opinion. It may be noted that the Institute of Transport when invited to state its views as a body to the Bridge Committee, deemed it inadvisable to do so.

The pros and cons of the case have been very fully set out by the Bridge Committee. On the one side we have æsthetic, archæological and other very lofty factors of undoubted weight—on the other the progress demanded by traders, and people of mercenary outlook. It is not the first time that ideals have clashed. Strong opposition was raised against the heightening of the Assouan Dam, and the submersion of Philæ. The utilitarians in that case ultimately carried the day, to the lasting advantage of Egypt. We have no desire to be classed among vandals and iconoclasts, but it may be remembered that we then sided with those who had the greater welfare of the country at heart. History since has fully justified that attitude. Similarly on the present occasion, with the Chairman of the Bridge Committee, we regretfully feel driven to the conclusion that, in the greater interests of London, a sacrifice now appears to be inevitable.

WATER POWER IN FRANCE.

The water power resources of France are capable of producing a total of 10,000,000 horse-power, of which 5,000,000 are available in the Alps, 2,000,000 in the Pyrenees, an equal amount in the mountainous districts in the centre and in the east of the country, and 1,000,000 in other regions. So far, one-fifth only of the total has been turned to account and this proportion serves to produce annually 3,000 million kw.-hours. The maximum amount of water power available in France may be said to correspond to the power derivable from a consumption of 100,000,000 tons of coal, and to be capable of producing 100,000 million kw.-hours. The total quantity of coal used annually in France amounts to 65,000,000 tons, of which about 25,000,000 tons are imported. On the above basis, the French coal would be capable of producing 40,000 million kw.-hours. It is believed that the coal output of the country could be raised to 50,000,000 tons annually, were it not for the scarcity of labour at the collieries. This latter figure would correspond with an output of 50,000 million kw.-hr., and is, as will be seen, exactly half the energy which can be derived from the complete utilisation of the water power resources existing in the French mountainous districts. Gradually, as these resources are turned to useful account there should be a corresponding saving in coal. This is much to be desired, and a possibility to which French economists are eagerly looking forward.

The figures we have given above are taken from the *Houille Blanche* year-book for 1924-1925, edited by Mr. A. Pawlowski, and published by the Paris Revue Générale de l'Electricité. This states that in the Alps, where hydro-electric power station work was first started, the flow of the streams is large, but the heads are generally low, the steepest gradients being found on the Italian slopes. The reverse is the case in the Pyrenees, where the steepest gradients are not on the Spanish but on the French side of the mountains, and series of mountain lakes afford natural storage. In the mountainous districts of the centre of France, the streams are not as a rule fed by glaciers, and their flow varies greatly with the seasons of the year; the heads are low as a rule and the utilisation of the water power resources in this instance, involves the construction of expensive large capacity reservoirs. In various parts of the country, thermal power stations have been very successfully coupled up with hydraulic power stations located at a distance, for regulating the current supply.

It is interesting to note that several French technical colleges have recently added to their installations well-equipped laboratories for the study and the testing of hydraulic machinery. Subventions granted by the Hydraulic Research Committee of the Ministry of Public Works have enabled the Nancy Technical College to put down special plant for carrying out researches on the construction and operation of water turbines, as well as for testing hydraulic and electric machinery on behalf of private companies. The Nancy College was largely developed in past years as a result of liberal contributions made to it by influential industrial men in the district and by the Ministry of Public Instruction. The Grenoble Polytechnic Institute, in the Alps region, has been for the last thirty years actively giving instruction in electricity and other sciences bearing upon the various industries of the town and locality. Its laboratories are completely equipped for electric, electro-chemical, electro-metallurgical researches and tests. They have also specialised in hydraulic power research and in the testing of hydro-electric power stations. Another French educational centre is at Toulouse, in the Pyrenean region. This is the Electro-technical Institute, which forms part of Toulouse University, where laboratories are set apart for researches in all matters connected with the utilisation of water-power, subsidised by the Ministry of Public Works and other bodies.

The French Government, acting in conjunction with a financial company, are putting down an experimental plant near Brest for the production of current by power derived from the sea; this is the Aberwracht power scheme. It involves the construction of a sea barrage, built up of caissons. The central caisson, 115 ft. in length and 73 ft. wide, is to be provided with the electrical machinery, driven by reversing water turbines. The scheme involves also the construction of a dam on land to regulate the flow of the river Diouris, and increase the storage capacity at the back of the sea barrage. When the work is completed, it is estimated that the plant will be capable of an annual output of 11,000,000 kilowatt-hours. The total expenditure on the installation is estimated at 25,000,000 francs, a sum which includes 2,000,000 francs for transmission lines. Work of a similar nature, but on a much smaller scale, is being proceeded with at the Arguenon estuary, to the west of St. Malo. At Guyotville, near the town of Algiers, a plant of another kind is stated to be in course of completion, in which a series of floats actuated by wave motion are to drive electrical machinery.

BICENTENARY OF NICOLAS JOSEPH CUGNOT, 1725-1804.

On February 26, two hundred years ago, Nicolas Joseph Cugnot, the constructor of the first vehicle driven by steam, was born at Void, in Lorraine. A military engineer by profession, Cugnot saw active service in the Low Countries, and then settled in Paris, becoming what to-day we should call an army tutor. He also wrote on military matters.

In 1766 he published a work on Ancient and Modern Warfare, followed three years later by another on the Art of Fortification. It was at this time that he turned his attention to the construction of a steam-driven carriage. His first was made in 1769, and his second in 1771. Of the former there are but few particulars. Though there is evidence it ran, the boiler was not equal to the demands made upon it. It leaked considerably, and the carriage had to be stopped after running from 10 minutes to 15 minutes for the steam pressure to rise again. The trial, however—witnessed by the Minister of War, the Duc de Choiseul, General Gribeauval, and numerous others—was sufficient to demonstrate the value of the invention, and Cugnot was authorised to build a second machine.

Cugnot's first steam vehicle had carried four persons, but the second was intended to take a load of between 4 and 5 tons at a speed of 2½ miles an hour. The machine is still in existence, and is one of the historic treasures of the Conservatoire des Arts et Métiers. A model of it is to be seen in our own Science Museum. Most of the information available regarding its history is found in a paper by General Morin, published in the Comptes Rendus of the Paris Academy of Sciences for 1851. The paper contains reprints of some documents relating to the machine, and among these perhaps the most interesting is the letter from General Gribeauval to M. de Chateaufer, Director of the Artillery at Strasbourg, ordering the cylinders and pistons. Gribeauval, famous for his defence of Schweidnitz against Frederick the Great, had himself made improvements in artillery, and was evidently eager to put Cugnot's plans in action. His letter, dated April 23, 1770, runs:—

"Il est nécessaire, Monsieur, qu'aussitôt que ma lettre vous sera parvenue, vous fassiez exécuter à la fonderie de Strasbourg deux pompes de 14 pouces de longueur intérieure et de 12 pouces de diametre aussi interieure, avec deux têtes de pistons de 12 pouces de diametre et de 4 lignes d'espaisseur, le tout conformément au dessin que vous trouverez ci-joint. Lorsque ces pompes et ces pistons seront prêts, vous les remettrez au commissionaire du sieur Biétrix pour les faire passer, sans perte de Temps, au sieur Mazurier, garde-magasin d'Artillerie à l'Arsenal de Paris."

By the middle of the summer of the following year the work was practically complete, and Gribeauval wrote to the Minister of War on July 2, 1771:—

"J'ai l'honneur de vous adresser une mémoire pour vous rendre compte de l'état de la voiture à feu de M. Cugnot dont j'ai en celui de vous parler. Cette voiture est à l'Arsenal de Paris; if suffira d'avertir l'inventeur huit jours d'avance quand il vous plaisa d'en ordonner l'epreuve."

The machine consists of a strong timber frame with three wheels, carrying in front a form of haystack boiler, with an internal fire-box. The two cylinders made at Strasbourg were placed just to the rear of the boiler. They were high-pressure single acting, with steam distribution by a four-way cock. The piston rods drove the front wheel by pawls acting on two modified and reversible ratchet wheels. A rocking beam was used for bringing each piston to the top of its cylinder after each working stroke. The cost of the machine was about 800*l*. Though built with considerable expedition, and evidently regarded in some quarters as a notable invention, there is no evidence that it was ever tried. For many years it remained in the Paris Arsenal, just escaping destruction at the hands of some of the revolutionaries, but at length, in 1801, was handed over to the Conservatoire des Arts et Métiers.

Of the later career of its designer, Cugnot, but little is known. During the Revolution he retired to Belgium, where for a time he lived in extreme poverty, but under the Consulate returned to France, and through a report of Lalande, Messier and Prony to the National Institute, Napoleon granted him a pension of 1,000 livres. He died in Paris, October 10, 1804, an old man of 79.

DEMOCRACY AND DEFINITION.

NOTHING is perfect, and it needs no great skill to find fault with the existing order of things. This indeed has become a passion with some people, but few of them agree upon the best way of putting things right. One man proposes to reconstruct industry, another the social system. But neither pauses to consider whether industry as reconstructed by the one will fit in with the social system as reconstructed by the other. None the less men of otherwise widely differing views would appear to agree that whatever else happens, we must adhere to "democratic" principles. The word democracy is on all lips, and is constantly referred to as something pregnant with human welfare. "The great tide of democracy is rolling on, and no hand can stay its majestic course." Sentiments of this type are certain of applause, especially when aired at the street corner. This being so, it is pertinent to enquire just what is meant by the word itself.

Now it is astonishing that though abundantly used by many, this term is seldom given clear definition. Even those who do enquire what it means generally resemble jesting Pilate, in that they will not stay for an answer. It is true that a few definitions have been attempted, but these are as often as not in semi-facetious vein. One tells us that democracy is a system which endows men with the utmost freedom to discharge their responsibilities on to the shoulders of others, and with the widest range in selecting a culprit for whatever goes wrong. Another, that in practice democracy implies the bludgeoning of the people, by the people, for the people. Yet another, that democracy means riding first class with a third class ticket. And even when one comes to a serious definition like that of a distinguished economist, that: "Democracy is simply a form of government," it does not throw much light on the matter.

The fact is, the word has been used for so many different purposes that in the end it has come to have no definite meaning at all. In this it resembles a great number of other words in common use—liberty, freedom, socialism, progress, and so forth; words which are freely bandied about without definition, everyone interpreting them to suit his own notions and the passing needs of the moment. Men have become so used to them that they are accepted as representing definite realities; and, by no one more so than the half-educated type of reformer. Yet without definition they are in truth no more than shadows, and very vague shadows at that. But so real do they seem that even to question their reality is to lay oneself open, in times of emotional stress, to the charge of being either a fool or a knave. Men collectively will hold up industry, and even wage war on their fellows on behalf of words which they are quite incapable of defining—words which have become mere symbols serving to focus their loyalties, their suspicions, and their hatreds. So potent have some of such words become that many of our social and industrial troubles arise from little more than the loose and careless use of abstract terms; a procedure as dangerous as the loose and careless handling of high explosives. To such carelessness may be traced many of those strikes, enmities and wars which in the end lead to nothing but disaster. Men weave about themselves and each other a network of misunderstandings, which ultimately becomes "a fateful screen that friendship cannot pass, and love beats his soft wings against in vain."

As people think, so will they do. Muddled thought invariably leads to muddled effort. So long as men give a variety of meanings to any one term, or identical meaning to terms which have widely different implications, so long will they rush into conflict needlessly. This is not to imply that men should all think alike. But where they differ, their differences should be clearly defined. Next to agreement, a clearly defined difference of opinion is the finest solvent of social conflict. For conflict in most instances arises through indefinite thought and expression, not from an honest understanding and rejection of points of view different from one's own. One would like to hope that there may be a great future for the first leader of men who will clearly define the terms he habitually uses, and that the age in which multitudes are to be swayed by much sound and little sense will pass, the number of conflicting voices becoming too great; agitators piping, but the people no longer dancing—any more than they will dance to a multitude of competing steam organs at a fair. In that happy time those who put their trust in vague words and phrases will find all the virtue departed from them, and we may hope to see a leader arise who, aspiring to make the world safe for "democracy," will begin by defining it.

THE INNER STRUCTURE OF ALLOYS.

ON Monday last, the 23rd inst., Dr. Rosenhain, F.R.S., delivered his second Cantor Lecture at the Society of Arts, on "The Inner Structure of Alloys." After recapitulating briefly his first lecture, of which a précis was inserted in our last issue, he stated that pure metals were sometimes found in alloys, but there were found also solid solutions and intermetallic compounds. In these constitutions there were crystalline substances, each crystal being homogeneous in composition throughout the crystal and from one crystal to another. There were two conceivable ways in which the two kinds of atoms in a crystal might be arranged, viz.: the lattice might be occupied indiscriminately by either kind of atom, just as a bricklayer using red and white bricks might set them anyhow in a wall. The other alternative was that the lattice remained the lattice of the soluble metal, but other atoms were pushed into the interstices, so to speak. At first sight it might seem difficult to discriminate between the two, but if the atoms of the solute displaced the atoms of the solvent the resulting crystal would have a perfectly calculable density. The weight of each atom was accurately known and by X-rays the spacings could be measured; a comparison of the density calculated from these measurements with the actual density showed that in all truly inter-metallic alloys, the atoms of the dissolved metal must be placed on the lattice of the solid metal and not interstitially, the only exception being the iron-carbon alloys above the gamma region. Exactly how the carbon was placed in these was unknown; it might be a case of definite chemical combination, each carbon atom being attached interstitially in some special way to three of the iron atoms. That was apparently exceptional, and no other case had been found in other alloys. Broadly speaking, the substitution hypothesis was definitely established.

If the substitution hypothesis constituted a correct interpretation of the facts in regard to solid solutions, two things followed. In the first place, one atom could not be replaced by another and maintain exact equivalence with the other atoms surrounding it. The lattice was slightly distorted by the presence of the stranger atom.

Distortion in the lattice by the introduction of a stranger atom represented a storage of energy, and the lattice was only capable of storing a certain amount of energy. If this limit were exceeded we got a different lattice in which the two kinds of atoms were built together freely, or a liquid, or even an under-cooled liquid—namely, a liquid of so low a temperature as to be quasi-solid.

The distortion in the lattice might be of two kinds, both of which would generally be present. Thus the distortion might be confined to a small region around each stranger atom, or there might be a general widening effect or a narrowing of the lattice as a whole. As an illustration, Dr. Rosenhain instanced the piling one on another of india-rubber sheets with the interposition of steel balls, when there occurred a large amount of distortion in the vicinity of the balls. If steel sheets were taken instead of the india-rubber ones there was no distortion of the sheets, and the thickness of the whole pile was increased by the interposition of the steel balls. In the case of the india-rubber sheets the occurrence was analogous to local distortion of the lattice, and in that of the steel sheets it was analogous to a general distortion of the lattice. It followed that if the lattice was stiff and rigid—in other words, where the metal itself was hard—there would be a general distortion and not much local distortion, whereas for a metal having a low melting-point there was a large amount of local distortion and not much general distortion. If distortion was localised the maximum possible distortion between any two atoms would soon be exceeded locally and the lattice would tend to break down locally, therefore the hard metals having high melting-points tended to form solid solutions of high concentration. The soft metals, such as lead and tin, formed scarcely any solid solutions. Harder metals, such as aluminium, formed limited ranges; copper rather more extensive ranges. Iron formed solid solutions freely, nickel and cobalt more freely, and tungsten and molybdenum most freely.

When a soft metal crystal underwent plastic deformation the lattices slid over each other. In a perfectly regular lattice the planes of sliding were true planes and the resistance to sliding was comparatively slight. The introduction of a stranger atom which caused local distortion resulted in the surfaces being no longer plane, but more or less humped. The freedom of sliding was thus reduced so that the introduction of stranger atoms produced stiffening of the metal. The more an atom produced distortion in the lattice the more it would harden the lattice and produce resistance to sliding. The extent to which a stranger atom produced distortion locally determined the number of stranger atoms a lattice could accept without breakdown. The hardening effect of the atom and its solubility in the lattice should be, roughly, inversely proportional to each other. This was verifiable from our knowledge of the alloy systems. Thus, alloys of copper and nickel were soluble in solid copper in any proportion; the two were miscible. In the case of zinc this could only be added to the copper lattice to the extent of 30 per cent. and the hardening effect was much greater. Aluminium could only be added to the extent of 7 per cent. or 8 per cent., the hardening being still greater. Tin could only form a still shorter series of solid solutions, with yet greater hardening. A pure metal melted at a single temperature. As the temperature rose the lattice expanded. The lattice parameter increased proportionally to the expansion of the metal. If there was a limiting inter-atomic distance beyond which the atoms could no longer hold together, when the lattice expanded the atoms would "let go." In a regular lattice the inter-atomic distances were uniform and the atoms would "let go" at the same temperature.

This was not the case with a solid solution, in which at some places the atoms were further apart, whilst at others they were closer together. The result was that melting began at a low and stopped at a higher temperature. There was thus a lowering of the melting range following upon an expansion of the lattice. When, however, the stranger atom caused a contraction of the lattice, as with copper nickel, it produced a rise of melting point.

When the stress applied to the lattice distorted it beyond its safe limit of "distortability," the lattice broke down and what was formed was similar to a liquid layer, a layer in which the atomic bonding was no longer uniform, as in the lattice. It was difficult to avoid the conclusion that there must be some such disturbance at the crystal face. Dr. Hanson and Mr. Gough had the idea that there must be, therefore, in addition, a wave of distortion passing through many layers of atoms in the lattice on each side of the plane of disruption. If the mere fact of replacing one atom by a stranger atom whose field of force was slightly different was to produce a large amount of distortion, the disarranging of a layer of these atoms must leave the others under conditions of mutual attraction and repulsion quite different from that which existed inside the regularly arranged lattice. Consequently, one would expect to find a distortion of the lattice on each side of the plane of slip. This had perhaps much to do with the hardening effect of cold work. It was quite sufficient to produce a very material change in the properties of the material.

In certain circumstances the amount of distortion produced by a stranger atom varied with the

temperature. A crude, but illustrative, view was that some atoms expanded more rapidly than others. At one temperature they would pack together more than at another. The variation in the field of force with the temperature would be different at different times, and the relative distortion would also vary. If the lattice were packed as full as possible at a high temperature and cooled rapidly, there would be no time for rearrangement and a solid solution would be preserved intact in a metastable condition.

If the temperature were raised a little, the superfluous stranger atoms would be ejected from the parent lattice and would tend to form a lattice of their own. With a lattice distorted to the maximum extent, there would be a hardening effect such as was expressed by the terms quenching, tempering, age-hardening, &c. The dissolved atoms were trapped in a position in which they caused the maximum distortion of the lattice. A lot of that distortion disappeared with a little more heat application and in a little more time, and softening and increased ductility resulted.

An attempt had, the lecturer proceeded, been made to determine the rate of diffusion of lead, *i.e.*, the rate at which the atoms moved about in their own crystal lattice, the idea being that diffusion occurred somehow in the crystal lattice. Radioactive isotopes of lead were used, dissolved in non-radioactive lead. No diffusion, however, took place. The isotopes were so much alike that they caused no distortion; short of melting no diffusion could take place. In organic crystals Tammann had shown that diffusion was impossible until the melting point was closely approached.

The cohesion between adjacent crystals was, Dr. Rosenhain said, known to be at least as strong, if not stronger, than the cohesion existing across the crystal planes. There were two possible ways in which crystals might unite. It might be assumed that they approached each other only within a certain distance, a kind of transition stage existing between the two. The lattice would then have to be distorted, on one side to maximum extension and on the other to the greatest possible compression. Thus there would be a definite maximum radius of curvature which the lattice could assume. If the crystals were large the result would be that the radius of curvature would be of the order of 1 per cent.; the region of transition between the larger crystals would be comparable in size with the crystals themselves. Microscopic evidence clearly showed that nothing of that sort occurred. The boundaries between the crystals were not absolutely sharp, and were not by any means wide. The remaining alternative was that there must be a heterogeneous arrangement of atoms in which the maximum lattice parameter was never exceeded. There was no crystalline marshalling; the atoms attached themselves to each other in the best way they could, but not with the complete number of bondings normally assumed in the lattice. If it were a question of mere pulling apart, such an arrangement would be weaker than the crystals. The crystals, however, did not fail by pulling apart, but by slipping; whilst the boundary could only fail by pulling apart. When consideration was given to the fact that the actual strength of inter-atomic bonding—calculable by the work done by various physical means—against direct pull was many thousands of time greater than the actual strength of metals in the amorphous assembly, the number of bonds which were really attached was only one-fourth or one-fifth of the total.

National Association of Supervising Electricians.—The annual dinner of this Association was held at the Holborn Restaurant on the 14th inst. and proved a very successful function. Mr. Bramner, the Secretary, had succeeded in getting together a distinguished list of guests, which included Sir Burton Chadwick, Mr. W. H. Patchell, President of the Institution of Mechanical Engineers, two past-presidents of the Institution of Electrical Engineers, and Mr. A. Page, one of the Electricity Commissioners. A third past-president of the Institution of Electrical Engineers was also present, of course, in the person of Mr. F. Gill, the President of the Association. The toast of the evening, that of "The Association," was proposed by Mr. W. H. Patchell, who pointed out the importance of the Association as a link between the employer and his workpeople.

NOTES.

The British Corporation.

In presenting the Annual Report of The British Corporation for the Survey and Registry of Shipping at Glasgow on Wednesday, February 18, Mr. Robert Clark referred to the fact that, although British yards produced 64 per cent. of the world's tonnage in 1924, the average only amounted to 48 per cent. during the last three years. Past supremacy counted for little in international competition in shipbuilding, and the largest proportion of orders would ultimately go to the country which turned out good work quickly and cheaply. Last year the total tonnage built for registration by the British Corporation as B.S.* was 254,000, as compared with 204,000 in 1923. Exactly one-half of the registered new tonnage in 1924 was built in foreign yards, whereas the proportion was only one-third in the previous year. In addition to this new tonnage, 159,000 tons already built have been classed, making the total addition to the 1924 Register 413,000 tons. In the thirty-four years of its existence, ships with a total of 6½ million tons have been built under the special survey of the British Corporation, and, of these, over 5 million tons were now on the Register. For many years, Mr. Clark said, they had been led to believe by experience and practice that the satisfactory measure of the suitability of mild steel for shipbuilding was given by the material not breaking under a pull of less than 28 tons per square inch. A change of outlook had been shown by some authorities, and they now accepted, without any change in dimensions, steel which broke at 26 tons per square inch. One question of importance in connection with the metal used in shipbuilding was the possible application of special steels of improved qualities as regards elasticity and ultimate strength. Recent losses among ships carrying coal in bulk had caused grave concern to the general public. The people responsible for the design, construction and use of such vessels should be brought together to determine the best methods by which such casualties could be avoided. Mr. Maurice E. Denny later reviewed the work of the Technical Committee and referred to the modifications introduced into the rules of the Corporation during the year.

The Properties and Structure of Quartz.

In the fourth, and concluding, lecture of his course on the above subject, delivered at the Royal Institution on February 19, Sir W. H. Bragg, F.R.S., said that when the β form of quartz (obtained on heating the ordinary crystal to 575 deg. C.) reverted to the ordinary type, it was not always able "to make up its mind" as to whether it would be right-handed or left-handed, so that it frequently twinned on cooling. Twinning, he said, always occurred on a face which might be a crystal face, and was an indication that, on building up a new layer of molecules on an existing crystal face, there were alternative methods possible, one of which was the right one, and somewhat the easier for the molecules to adopt, although in the other alternative the molecules fitted into the face very nearly as well. If they did adopt this second alternative, the crystal was continued as a twin. The piezo-electric properties of quartz he attributed to the silicon atoms having a slight positive charge and the oxygen a slight negative charge. If a slab of quartz were distorted, the slewing round of these atoms caused one face of the slab to appear positively charged and the opposite face negatively charged. The effect was not observed if the slab were subjected to a uniform hydraulic pressure. The quartz crystal possessed a certain slight conductivity for electricity. It was found, however, that polarisation occurred, and this was attributed to ions being able to pass through the quartz and to collect on opposite sides. If a slab were cut out of the middle of a crystal thus polarised, it was found that this had a lower conductivity than the rest of the crystal. This rendered it probable that the conductivity was due to the presence of impurities which were able to pass through the crystal. An examination of the arrangement of atoms in the latter showed that along the principal direction there were "holes" in it, through hexagonal rings of oxygen atoms. These rings measured rather more than 2½ Angström units across, and, in this direction, both lithium and sodium atoms seemed to be able to pass through the crystal. In the transverse direction there were "holes" about ½ an Angström unit smaller, and lithium could pass through the crystal in this direction, but the sodium atom could not. Fused quartz, when hot, the lecturer showed, was pervious to helium. The fused quartz had a specific gravity of 2·2, whilst that of the crystal was 2·6. The key to the structure of the latter lay in the fact that each silicon atom was the centre of a tetrahedron the corners of which were occupied by oxygen atoms. The X-ray analysis seemed to indicate, moreover, that the valency bonds of the oxygen atom did not lie in the same line.

Mineral Resources of the United States in 1923.

During the year 1923, most of the branches of the mineral industry of the United States, appear, from the sixth annual preliminary summary drawn up for the Geological Survey, to have recovered their pre-war vigour, with the possible exceptions of soft coal, copper and precious metals. As regards soft bituminous coal, the continued uncertainty in the labour field caused active buying and heavy purchases, especially by the railroad companies, and maintained full-capacity production, so that the final total output of probably 552,000,000 short tons has only twice been exceeded, viz. in 1918 and 1920. Similar conditions prevailed in the anthracite trade. A deficit of 40 per cent. left from 1922 was soon wiped out, and, in spite of labour troubles, the production was almost equal to that of the war years 1917 and 1918. The great activity in the iron and steel industry, and the shortage of household coke, had the same effect on the coke production, which, amounting to 55,487,000 short tons, came within 2 per cent. of that of the record year 1918. Two-thirds of the coke came from by-product ovens, which reached their maximum output, and one-third from bee-hive ovens. With petroleum all records were broken. The total production of 733 million barrels was higher by 32 per cent. than that of 1922, and was 39 million barrels greater than that of the world's oil production of 1920. The great output was largely due to flush yields in California, Oklahoma, Texas and Arkansas. The decreased oil production in Mexico, on the other hand, caused a peculiar condition in the shipments through the Panama Canal. The over supply of crude oil in 1923 soon sent the prices down, and with 1924 a sharp check to production set in temporarily; while that may not continue, the peak of oil production in the United States seems to have been passed. The output of precious metals increased, but the metals depreciated in purchasing power. The smelter production of copper increased by 31 per cent. over that of 1921; it also increased in South America and Africa, however, while the European consumption of copper went down. As regards zinc, the Jopling district of Missouri produced 60 per cent. of the world's output. A new record was made in pig iron, and the activity in iron and steel raised iron-ore mining almost up to the peak of the war years. The tariff of September, 1922, did not encourage manganese production to any extent, partly because the stores of ore were large. All the cobalt came from Canada, none being produced in the United States. This has also applied to nickel since 1920, but matte from New Caledonia and Canada is being refined by two large companies. Uranium and vanadium are classed together. The vanadium is practically obtained as a by-product of radium; the radium productions (radium in salts) for the years 1920, '21, '22, and '23 was 32·5, 35·7, 24·1 and 12·2 grammes, respectively.

The Power of Internal-Combustion Engines for Motor-Cars.

In discussing Mr. A. E. Berriman's paper entitled "A Review of the Rating Question" in our issue of January 30 last, we referred to the much-discussed question of altering the basis of motor taxation, particularly in the class of private cars. We pointed out some of the difficulties that would have to be

overcome in making such a change, and expressed our agreement with the conclusion reached by Mr. Berriman that, so long as a fuel tax is impracticable, it seems preferable to retain the known conditions of the present system rather than to risk the reactions of a change. In dealing with the same subject in a paper read before the Royal Society of Arts on Wednesday last, Sir Dugald Clerk stresses the unfair advantage, from the point of view of taxation, given to owners of cars fitted with engines having an actual power output very greatly in excess of the Treasury rating. It is only fair to point out, in this connection, that the market is perfectly free to all, and that if a buyer purchases a car in which the maximum power of the engine is only slightly in excess of the Treasury rating, in preference to one of the type referred to by Sir Dugald Clerk, he probably has perfectly sound reasons for his action. Amongst these, perhaps, the most potent is the fact that an engine designed to develop a power of three or more times its Treasury rating is very expensive to construct, and, in consequence, the first cost of a car fitted with such an engine is proportionately high. The choice of the purchaser thus lies, to some extent, between a car of low first cost but relatively high taxation, and one possessing the reverse characteristics. The purchaser of the former type of car pays a greater proportion of his motoring costs into the National Exchequer, and less to the manufacturer, but his cost per mile over the time he possesses the car may be much the same as if he had purchased the car with the under-rated engine. The question thus appears to be one affecting the taxation authorities rather than the owners of private vehicles. In his paper Sir Dugald Clerk stated that he had recently gone over the mass of information available on the rating question in an endeavour to find some method of rating which allows complete freedom to designers as to cylinder dimensions and proportions, while leaving no room for such extensive evasion as has proved easy with the R.A.C. rating. As a result, he finds a possible solution of the difficulty in a suggestion put forward by Mr. L. H. Pomeroy in 1912, to the effect that in the existing state of design the fundamental dimension of a maximum horse-power equation should be the area of the inlet valve. Sir Dugald Clerk analyses the performance of a number of engines from this point of view, and reaches the conclusion that 5 brake horse-power per square inch of inlet valve throat area would give a satisfactory rating to cover most existing engines. While agreeing that such a system of rating would result in a basis of taxation more nearly proportional to the true power of the engine used by each motor-car owner, we have said sufficient to indicate that a change to such a system of rating would have a profound effect on the car market, and the resulting position of a number of manufacturers who have developed types under the present system would be speculative in the extreme.

Lessons of the World Power Conference.

A joint meeting of the Birmingham and District Association of the Institution of Civil Engineers, the Midland branch of the Institution of Mechanical Engineers, and the South Midland centre of the Institution of Electrical Engineers was held in the Council House, Birmingham, on Friday last, the 20th inst. The subject selected for discussion was a review of the work of the first World Power Conference. The occasions on which the senior institutions meet on common ground are comparatively rare, and it therefore seems the more desirable that when the opportunity does occur the subject chosen for discussion should be one on which an exchange of views is likely to be particularly advantageous. It was admitted by more than one of the speakers that the wide terms of reference of the World Power Conference tended to detract somewhat from the results achieved, and it seems unfortunate that the subject selected for discussion at the joint meeting at Birmingham should, in effect, have been still wider in scope, as it was nominally proposed to deal with the work done at the conference in the space of two hours. We do not wish to suggest that the meeting was in any way unprofitable, as the wide experience of the three speakers representing the respective institutions enabled them to bring forward a number of interesting points on what is admittedly a well-worn topic. After reviewing the organisation of the conference, Colonel Crompton, who represented the Institution of Civil Engineers, expressed the opinion that on future occasions the most effective procedure would be for the National Committees to bring forward subjects of immediate interest as a basis for general discussion. He mentioned that a point of great importance which was not discussed at Wembley was the effect of power distribution throughout the country in ameliorating the conditions of the working classes. He drew a distinction between the cost of generation and the cost of distribution and suggested that the public were misled into the belief that the former was of primary importance, while the latter could be practically ignored, a reversal of the true state of affairs. Mr. D. A. Bremner, representing the Institution of Mechanical Engineers, suggested that we were on the eve of remarkable changes in the utilisation of our natural reserves of energy. Advances had already been made in the direction of utilising increased temperatures and pressures in steam generating plant, and it was quite possible that the gas turbine would be a commercial success in the lifetime of those present. He laid stress on the importance of extracting the heat energy available in coal economically and mentioned that, although experiments in the extraction of the energy contained in our great beds had been disappointing, recent work in this direction had been very encouraging. Mr. W. B. Woodhouse, representing the Institution of Electrical Engineers, pointed out that there was a limit to the distance to which electricity could be transported economically, and on this account England was in a favourable position owing to the wide distribution of her coal fields. He dwelt on the importance of a more careful consideration of the method of extracting the energy from coal, and expressed the opinion that we should be able to ensure our home supply of oil fuel by coal distillation in a reasonable time. He also referred to the fact that the ratio of power produced to workers employed was lower in our own country than in others and that on this account we were in a disadvantageous position. In conclusion, he suggested that a very desirable subject for discussion was the provision of a hot-water supply for the community, as at the present time this offered great difficulties from the electrical standpoint.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE Annual General Meeting of the Institution of Mechanical Engineers was held on Friday last, the 20th inst., the chair being occupied throughout the proceedings by Mr. W. H. Patchell.

The Annual Report.

The minutes of the previous meeting having been read, the annual report for 1924, which was taken as read, was adopted without discussion. Of this report we give the following summary :—

The seventy-eighth annual report showed a net increase on the roll of the Institution of 358 names, the total amounting at the close of 1924 to 9,585. The additions numbered 868, including one honorary member, 115 members, 196 associate members, three companions, 24 associates, 233 graduates, and 296 students. The total number of names coming under the heading of deductions was 510, of which 114 were transfers, the remainder representing deaths, resignations, &c. Excepting a decrease of five in the number of companions at the end compared with the beginning of the year under review, there was a net increase in each class, the largest figures being 179 in the case of students, 142 in the case of graduates, and 20 in each of the classes, associates and associate members. Among the losses by death the following names may be quoted :—Dr. William H. Maw, Past-President ; Viscount Pirrie, Sir Maurice Fitzmaurice, Colonel C. H. H. Nugent, Professor J. G. Longbottom, Mr. Lawrence Birks, Mr. F. J. Cribb, Mr. Thomas Lumsden, Mr. Robert Dyson, and Mr. T. H. Houghton. Of these Dr. Maw served on the Council from 1890, occupying the presidential chair in 1901 and 1902, and Lord Pirrie was a member of Council during 1899-1908 and 1912-14. Mr. Dyson had been a member from 1865, and Mr. Houghton was chairman of the Australian Advisory Committee from its inception in 1922. The accounts for the year showed a balance of 902*l.* of revenue over expenditure, compared with 1,037*l.* in the previous year. For the year under review the revenue was 32,334*l.* and the expenditure 31,432*l.* In connection with research, work for the Alloys of Iron Research Committee has been continued at the National Physical Laboratory. With regard to Cutting Tools, photo-electric investigations of the stresses in the work and tool had been carried out by Professor E. G. Coker ; by Dr. Walter Rosenhain at the National Physical Laboratory on the deformation of the metal which occurs in the formation of chips in cutting operations ; and by Dr. T. E. Stanton on the forces exerted on the surface of a cutting tool. The work of the Hardness Test Committee was continued at the National Physical Laboratory. Work for the Steam-Nozzles Research Committee had been carried on at Manchester under the direction of Professor G. Gerald Stoney. Shore and sea tests on "Camellaird-Fullagar" and "Doxford" engines had been carried out in connection with the Marine Engine Trials Committee, together with sea tests on "Scott-Still" and "Beardmore-Tosi" engines. Progress had been made by the Heat Engines Trials Committee composed of members of various institutions throughout the country. A sixth local branch of the Institution was formed during the year and will be styled the Western branch.

The Thomas Hawksley medal had been presented to Professor W. T. David and a premium to Dr. H. Moss. The Water Arbitration Prize was equally divided between Mr. E. Bruce Ball and Mr. Daniel Fife. The Willans Premium was awarded to Mr. P. C. Dewhurst, while prizes were secured by Mr. F. Adcock and Mr. E. L. Diamond. In connection with the examinations, a prize had been awarded to Mr. H. W. Cadman.

Election of Officers.

The Secretary read the ballot list for the election of officers, which was as follows :—As President, Sir Vincent Raven ; as Vice-Presidents, Engineer Vice-Admiral Sir George Goodwin, K.C.B., and Mr. Loughnan St. L. Pendred ; as Members of Council, Mr. James Brown, Mr. A. E. L. Chorlton, Professor E. G. Coker, Lieut.-Col. Davidson, Mr. W. P. Fanghaenel, Sir Archibald Ross and Major S. J. Thompson. In addition to past-presidents and vice-presidents elected to serve on the Council, the following chairmen of local branches had also been co-opted :—Glasgow and West of Scotland, Professor Mellanby ; Midland, Professor Hall ; North Western, Professor Stoney ; South Wales, Engineer-Commander Reynolds ; Western, Lieut.-Col. Pitt ; Yorkshire, Professor Charnock.

Owing to the enforced absence of the new President, Sir Vincent Raven, abroad, it was proposed by Sir Henry Fowler that Mr. Patchell should continue to act as chairman. This was passed, and Mr. Patchell having assented, Sir Henry proposed, and Captain Sankey seconded, a vote of thanks to Mr. Patchell as retiring president.

Auditors.

After acknowledgment of this by Mr. Patchell, Colonel Dalton proposed that Mr. Raymond Crane, F.C.A., be reappointed to audit the accounts of the Institution. This proposal was seconded by Mr. Bruce Ball and carried.

Anti-Friction Bearings.

The discussion was then resumed on the paper read on the 6th inst., entitled "Anti-Friction Bearing Applications for Heavy Duty," by Mr. J. B. Dahlerus.

Sir Henry Fowler said the application of roller bearings to rolling-stock was still in its infancy. From Sir John Aspinall's paper before the Institution of Civil Engineers some 25 years ago, he had taken certain figures from a curve in which the total resistances had been split up, and, proportionally, he believed the figures to be right at the present time. These figures related to a 20-coach train running at 20 miles an hour, and, roughly, the journal resistance was not more than 30 per cent. of the total. At 60 m.p.h. this resistance amounted to 11 per cent., while at 80 miles per hour the figure was 9 per cent. It would be seen, therefore, that only a comparatively small amount of the total resistance to traction was under consideration. This might explain why, when running at high speed for long distances, a saving such as was indicated by the Kentish Town-Leicester run, referred to in the paper, was not to be expected. He was convinced that a plain white-metal bearing, well lubricated was hard to improve upon. The aspect of the matter would, of course, be different when dealing with a vehicle which had frequently to start and stop, the resistance being then largely due to that in the bearing itself. With regard to Fig. 6 in the paper, he wished to ask Mr. Dahlerus if he would

explain how he correlated the curves Nos. 3 and 4 in that figure. In making experiments of this kind, it was, of course, very essential that the conditions should be absolutely comparable. Referring to Table IV, he desired to correct the figures given for net work done in working the train as measured by the integrator; this should be 3,484 million ft.-lb., instead of 4,484 as given. The difference in coal consumption per ton-mile in Finland and in this country might result from the character of the coal used in Finland.

Mr. Daniel Adamson emphasised the great importance of durability of bearings, especially when applied to rolling-stock. He had not been able to find in the paper any information as to the comparative durability of roller bearings and the white metal bearings in common use.

Mr. R. W. Reid, referring to the Midland Railway tests, stated that the reason for fitting roller bearings was the increase of weight of passenger stock due to increased accommodation and the limitations resulting from the gauge, bridge construction, &c. The figures put before his company by Mr. Dahlerus were largely based on results obtained in Sweden. Expectations in England had not materialised to the same extent. There was some advantage obtained at low speeds, but not when running at over 5 to 10 miles an hour.

American passenger trains had used "Skefko" bearings. Their trains were extremely heavy, and the main difficulty was in starting the train, in spite of the large locomotives employed. If the use of roller bearings enabled the trains to be started more readily the investment would be a good one. Their method of testing the friction of bearings was different from that in use here. Two dynamometer cars were used, one between the engine and train, followed by three cars fitted with roller bearings, and then another dynamometer car with three further cars fitted with white-metal bearings. When repeating the experiment, the order was reversed. By measuring the starting efforts they deduced that there was an economy in starting, and therefore the engines could draw heavier trains. The difference between the bearings used in this country and on the Continent was probably due to the higher standard prevailing here.

Mr. Daniel Fife spoke next. He alluded to a large ball bearing, of German origin, carrying—18 years ago—a load of 12 tons at 375 r.p.m. Nothing like it had been made since. The shaft was 10½ in. in diameter, and the weight of the flywheel was 16 tons. These bearings were mounted on a rocker, and had the advantage of self-alignment. The difficulty was with the end thrust. The flywheel was inclined to have end play. The bearings ran satisfactorily for a year; gradually the race became pitted and the balls chipped and fractured. Had it been possible to prevent end play of the flywheel, he felt that the bearing would have been very satisfactory. He agreed in advocating good metal for bearings required to carry heavy loads at high speed. He believed that unless the conditions of use were well considered ball or roller bearings would be likely to fail; every type had its place.

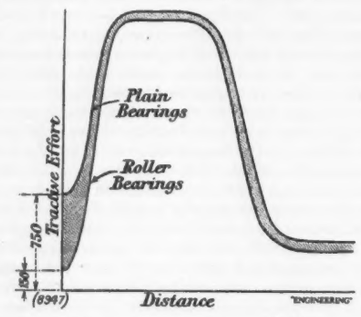
Mr. J. H. Hyde mentioned the Glasgow tramcar tests, in which starting effort tests made showed that a roller-bearing car could be moved by one man, whereas the plain-bearing car required three men to move it. Confusion often arose in respect to starting effort and accelerative force. When beginning to haul a car the tractive effort rose to a certain value, but when the car began to move an accelerative force was usually exerted. This force had to be maintained while the acceleration was constant, but the effort then fell to a value at which the speed could be maintained constant. For an eleven-ton tramcar the starting effort would be about 750 lb.; for a roller-bearing car the value would be reduced to, say, 150 lb.

The accompanying diagram showed roughly corresponding curves for cars fitted with plain and roller bearings, tractive effort being plotted against distance. The advantage of the roller bearing was given by the shaded portion between the two areas, and, as was evident, was relatively small in the early stages, when the effort was large. Roller bearings could not have, therefore, any great advantages for stopping services; the advantage would only be apparent when running on a long stretch. The statement made in the paper might erroneously be interpreted to mean that 79 per cent. could be saved in energy.

With reference to Table III of the paper, he did not consider that single tests could be taken as altogether representative. In the case of tramcars, he had made hundreds of tests; first with roller bearings and then with plain bearings—and had found that a 2 per cent. saving might be achieved in one instance, while in another the saving might be 40 per cent., even with the same conditions.

Sir Ernest Petter, in response to a question from the Chair, remarked that he could say that for any machinery which his firm made they adhered to white metal bearings.

Mr. J. D. Twinberrow suggested that the diameter of a journal should be the minimum consistent with strength. The standard axles for British use had journals in which the diameter was one-half the length, whereas in American practice this diameter was half-an-inch greater than half the length. By this course he thought the Americans might be adding about 10 per cent. to the value of the journal friction, without any benefit. In applying electric traction to railways, designers of rolling stock were apt to think bigger journals were needed, overlooking the advantage of minimum



diameter. End thrust was quite a serious matter with ordinary rolling stock. At high speeds, the lateral force upon journal bearings was 16 per cent. to 18 per cent. of the weight on the journal. Normally, collars on both ends of the journal dealt with this end thrust, the horn cheeks sharing the load between them. When the outer collar was dispensed with, the thrust was taken on one side only at a time.

Mr. F. J. Hookham said it had been stated that the same train could be taken over the same course—a fairly flat one—on the same day, under apparently identical conditions, and yet the results might vary by as much as 20 per cent. to 30 per cent. Isolated tests could not therefore be worth very much. He thought the condition of the track had a good deal to do with the better results shown for ball or roller bearings on the Continent. He thought smooth tracks assisted plain bearing lubrication, which gave the lowest coefficient of friction. He understood that ball bearings had been applied to train lighting dynamos, but had resulted in commutator troubles from chattering and wear, more than was the case when plain bearings were used.

Lieut.-Colonel A. E. Davidson, said he would like the author to express his views as to the most up-to-date practice in the matter of anti-friction bearings for big ends, particularly in motor vehicle work. The principal objection to the use of such bearings arose from the frequent breaking of the cages. The roller length was immaterial. The author, in laying down the characteristics for good anti-friction bearings, suggested that they should be non-adjustable, and with this he agreed. Experience with adjustable bearings on lorries caused the War Office to decide against them in 1912. After the outbreak of war, many American lorries, which had tapered roller bearings, were used and found to be better than the plain bush bearing lorry in use here: the American bearing was non-adjustable by the driver. On the question of the life of a bearing, the author had referred to a 4½-year life as inadequate and had noted a life of 7 years as satisfactory. He (Col. Davidson) had been supplied, in one instance, with a bearing which had to be replaced in four months; this might be as good as could be expected, but he was, nevertheless, dissatisfied.

Mr. E. Bruce Ball remarked that the paper dealt with bearings for heavy duty. Mention had been made in the paper of various applications including a small mill, but Mr. Ball would have liked the author to give his experience of bearings of much larger loadings—such as 15 tons to 20 tons per bearing. The previous speaker had mentioned the breaking of the cages for crankshaft bearings. Could the author give any information as to cages with packed rollers for heavy-duty bearings?

Engineer Rear-Admiral R. W. Skelton observed that a vast number of experiments had been made by the Admiralty, and that ball and roller bearings had not given satisfaction in the Navy. The development of the Michell thrust had stopped the investigations and made the "Hood" possible.

Mr. J. H. Kitchen referred to the author's mention of 1916 as the date when bearings for heavy duty first came into general use. A bearing was devised by Mr. Kitchen's firm in 1908, which resembled a cast-iron plummer block with recesses, fitted with rollers; the material was hard. Rollers were made of high-carbon steel. These bearings were applied to rolling stock, and it was found that a loaded wagon could be pushed about by an apprentice; 400 or 500 such bearings were made. He had since heard that the wagons were working satisfactorily.

Mr. F. C. Croxford said that any saving would be quickly eliminated by the occurrence of stoppages. He did not think that ball or roller bearings were economically sound. The race and the roller were ground perfectly circular, so that the point of contact should be infinitely small, and in theory the pressure, be the duty what it might, must be very high. The elasticity of the material available did not permit bearings and races to remain perfectly circular. In view of the millions of revolutions to which the rollers were subjected, obviously, in both rollers and races the skin of the metal would become deformed. In a railway vehicle, account had also to be taken of the constant hammering, laterally and axially, while on the track. This would set up serious fatigue.

Mr. G. P. W. Simms said that according to the author's figures the comparison was mainly between ball and roller bearings and the older type of plain bearings; the more recent plain bearing—the rocking pad type—was not referred to. Ball and roller bearings depended upon the material and its treatment. On the question of repairing large ball or roller bearings, he would ask if these bearings were repaired or were scrapped? Had Mr. Dahlerus any experience of applying roller bearings to heavy drives, particularly with gearing? In the case of reversing drives for rolling mills or winders, was the life of the bearing adversely affected by constant reversal? Makers of gears were disinclined to abandon the old type of bearing in which the oil film afforded a certain amount of protection and accommodation to the gear teeth, permitting the latter to take up their proper bearing and so promoting smooth running of the drive.

Mr. J. B. Dahlerus, in reply to some of the points raised, said the coefficient of friction for a plain railway bearing might be accepted as 0·007. In the case of an anti-friction bearing the coefficient was 0·001 to 0·003, affording a saving in journal friction of 75 per cent. to 80 per cent. The saving in total resistance was quite a different matter, depending upon air resistance, flange action, curves, gradients, &c. The starting resistance to be overcome was greater in the case of a train which had made a stop of an hour than in the case of one that had only stopped for a couple of minutes. A single test was not sufficient to obtain really reliable results. Comparisons should not omit the expense of maintaining plain bearings of high quality in good condition. With regard to the life of roller bearings the tests clearly indicated a life of 15 years to 25 years. An economy of 14 per cent. was realised during the three months

trials in Sweden, and the roller bearings paid for themselves inside four years to six years. It had been proved that maintenance costs were lower for roller bearings, as also was the cost of lubricant. On American lines there was an absence of hot axle-boxes, due to the type of roller bearing used. The cost of the box described was about 18*l*. An ordinary axle-box cost about 5*l*., and if the axle-box costs were compared with the total cost of the coach the increased cost of the roller-bearing axle-box appeared extremely small. The question of reliability became really a question of so dimensioning the bearings as to get the deformations of both races within the allowable limits. The load taken by the bearing would depend upon its diameter, but with a diameter of 5 in. to 6 in. a safe load of 50,000 lb. to 75,000 lb. could be carried at 500 revolutions; if the revolutions were reduced the carrying capacity would increase considerably.

The Chairman then closed the proceedings, announcing that to-night, at 7 p.m., there would be an informal meeting, the subject of discussion being on the "Practical Problems of Lubrication"; also that the Graduates' (London Section) Annual Dinner would take place to-night at the Engineers' Club. Further, that he would deliver the annual lecture to the Graduates on Monday, March 2, taking as his subject a visit he had paid to America; the lecture would be illustrated by lantern slides. On Friday, March 6, there would be an informal meeting when "Pitfalls for Patentees" would be discussed. An extra general meeting would be held on Friday, March 13, at 6 p.m.; two reports on "Cutting Tools," respectively by Professor E. G. Coker and Mr. Dempster Smith, would be read and discussed.

LABOUR NOTES.

THE National Minority Movement announces in its official organ that it has begun a campaign to force the leaders of the miners, engineers and railwaymen to make their present "fight" a common one in which the various unions "will stand by each other in the attempts to realise the various demands" which have been officially put forward. The workers everywhere are exhorted "to establish Committees of Action." "A mass movement created by the workers themselves will develop," it is declared, "such power that the existing leadership will be either forced to go forward in a common struggle, or . . . be swept aside and a new leadership, capable of really leading the fight, established." The workers are told to "organise demonstrations and joint meetings to support this policy," and to "exchange speakers from the different industries." "Form the local Joint Committees," it is added, "if Black Friday and all that it has meant is not to be repeated."

Elsewhere in the same publication, trade union branches which desire to affiliate to the National Minority Movement are informed that where a local general fund, benevolent fund, or political fund exists, it can be used to pay the affiliation fee. Where no such fund exists, the instruction proceeds, "take a collection of the members and pay the fee quarterly, if this method is likely to remove the present obstacles."

On the first of the points raised by those pronouncements, the executive of the Amalgamated Engineering Union has made its position perfectly clear. It considers, Mr. Smethurst, in effect, says, that the interests of the Society can be best served by the membership taking its share of the work under the provisions laid down in the rules. "To create a movement outside the union is," in the opinion of the General Secretary, "to disintegrate, and if ever there was a need for unity in our ranks, surely, it has been," he says, "during the past few years." On the other point, the Council has decided that the funds of the union cannot be used, nor any levies be raised and charged upon members' cards for the purpose of paying delegation or any other expenses in connection with National Minority Movement conferences.

The Industry Tables, based on the census of England and Wales in 1921, which have just been issued by the Stationery Office, contain much valuable matter. The table distinguishing the sex and age, in 12 age groups, of all occupied persons, 12 years and over, is extremely interesting. It shows a steady rise in numbers up to the span of years between 25 and 34, when a decline sets in, much more marked at first as regards women, until the span from 55 to 59 is reached. In those five years nearly two-thirds of the men drop out. The exact figures are:—Males, 45 to 54 years, 2,063,125; 55 to 59 years, 734,825—a difference of 1,328,300. The number of men of 70 and over returned as employed was 215,162, and of women 50,463. Of the men over 70, 34,252 were engaged in farming, 2,624 in market gardening, 995 in flower and seed growing and nursery gardening, and 4,371 in other kinds of gardening. There were 8,408 men over 70 employed in coalmining (of whom 1,754 were hewers), 2,704 in shipbuilding and marine engineering, 3,057 in tailoring, 5,032 in boot and shoe and slipper manufacturing, 2,246 in general carpentry, 12,516 in building and contracting, 2,429 in railway transport, 2,660 in the retail grocery trade, 10,192 in the service of local authorities (excluding those employed in tramways, gas, water, and similar undertakings), 3,509 in religion, 9,829 in domestic service, 2,736 in hotels, inns, &c.

Important gatherings are taking place in Germany this week-end for the purpose of demonstrating the adherence of the workers to the principle of the eight-hours' working day. To-day (Friday) a large meeting of metal-workers is to be held at Frankfort, and amongst the speakers who have promised to take part in it is Mr. J. T. Brownlie, president of the Amalgamated Engineering Union and secretary of the British Section of the International Federation of Metal-workers. To-morrow there is to be a meeting of the executive of the Metalworkers' International, and on Sunday and Monday meetings of metal-workers, including representatives of the men employed in the blast-furnace and steel-smelting industries, are to be held. The latter gatherings, which are to be preceded by an imposing march, have been organised by the German Section of the Metalworkers' International, and their object is officially stated to be "to consider how the 48-hours week may be maintained in Germany."

The Moscow correspondent of the *Soviet Union Review* states that the scientific institutions concerned with industrial research have for some time past been devoting much attention to the question of Industrial Standardisation, and, besides conducting an extensive inquiry into local conditions and methods of production in the Union, have been carefully studying such systems of industrial standardisation as are current in the United States and Western Europe. As an outcome of the recommendations of the various organisations which were concerned in the inquiry, a permanent committee has now been formed which is attached to the Council of Labour and Defence. This body is to be entrusted with the drawing up of standard specifications for materials and machinery, the collection of the requisite information, &c. Provisional standards have been drawn up for water-pipes, agricultural machinery, textiles, &c. The committee has plans for a complete standardisation of industry; but, it is added, a shortage of adequate funds is, unfortunately, likely to prove a serious obstacle in the way of their immediate application.

Whether Labour's political funds should be raised as at present or on the lines proposed by Mr. Macquisten's Bill is a question which, obviously, concerns the political side of the movement more than it does the industrial side. The controversy which is in progress may, however, have some undesirable effects on the industrial relations of employers and employees, and, on that account, it is a little unfortunate that it has arisen. Extremists are already telling the rank and file that the Bill is an attempt by Capital to overthrow Labour's organisation, and, although the average worker is, probably, lukewarm on the question of the levy, he is not unlikely to be easily misled by allegations of this kind, into the belief that the employers are behind the new proposal. With such a mistaken belief fairly general, the negotiation of purely labour affairs would, it goes almost without saying, become more difficult than ever.

The extracts, which have been published in advance, from the report of the Trades Union Congress Russian Delegation, suggest that Mr. Purcell and his colleagues did not very closely examine the industrial side of Soviet Russia's activities. We are told that, taking into consideration the facilities, &c., which the worker enjoys, his wages are higher than they were in pre-war days. What the exact value is of the "facilities" nobody has, so far, permitted himself to say. But according to Soviet official publications, wages in many Russian industries are actually much lower than they were in 1914. Output is also lower, although it is improving—chiefly because piecework is now being introduced on an extensive scale. Overtime—to which all Moscow's friends in this country strenuously object—is, moreover, permissible under conditions which closely resemble those obtaining in the engineering industry of this country.

The truth is, although no reference to it appears in any of the published extracts from the report, that Labour conditions in Soviet Russia are not very unlike those which have been mutually agreed to, after many years of experience, in Great Britain. Even the right of exercising managerial functions is now reserved to managements. Writing in *Torgovo-Promyshlennaia* on January 1, 1924, M. J. Bogdanov says that, "thanks to the wide experience gained during the period of re-organisation, the Soviet Government has come to the conclusion that the management of industry should be wholly entrusted to specified boards for the undertakings, and that it is impossible to divide responsibility." "Therefore," he goes on to say, "the responsibility for the satisfactory working of undertakings should attach exclusively to the economic authorities in charge of industries and the managements of undertakings. Normal co-operation with the trade unions cannot be established unless the latter abstain from interference with the administrative and economic measures adopted by the managers of undertakings."

The Ministry of Labour states that on February 16, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,239,800—943,100 men, 35,300 boys, 227,700 women, and 33,700 girls. On February 9, 1925, the number was 1,242,959—941,053 men, 35,882 boys 231,544 women, and 34,480 girls—and on February 18, 1924, it was 1,160,067—854,253 men, 36,750 boys, 232,155 women, and 36,909 girls.

Giving evidence before the Committee on Industry and Trade on February 24, Dr. C. S. Myers stated that the experience of the National Institute of Industrial Psychology during the four years of its existence indicated that a large increase in the quantity and quality of the "worker's" "output" (using these two terms in the widest sense) could be obtained in this country by more adequate consideration of the "human" factor. This factor involved the study of (1) factors, such as ventilation, temperature, lighting; (2) methods of work, including routing, arrangement of material, the worker's posture and movements, and the elimination of needless movements; (3) the most advantageous distribution of periods of rest and work; (4) the best methods of reducing monotony, increasing interest, introducing incentives, and of promoting agreeable relations between management and labour; (5) the selection and training by more systematic and scientific methods than heretofore, not only of the worker, but of the personnel of management throughout all grades, so as to obtain the best applicants available.

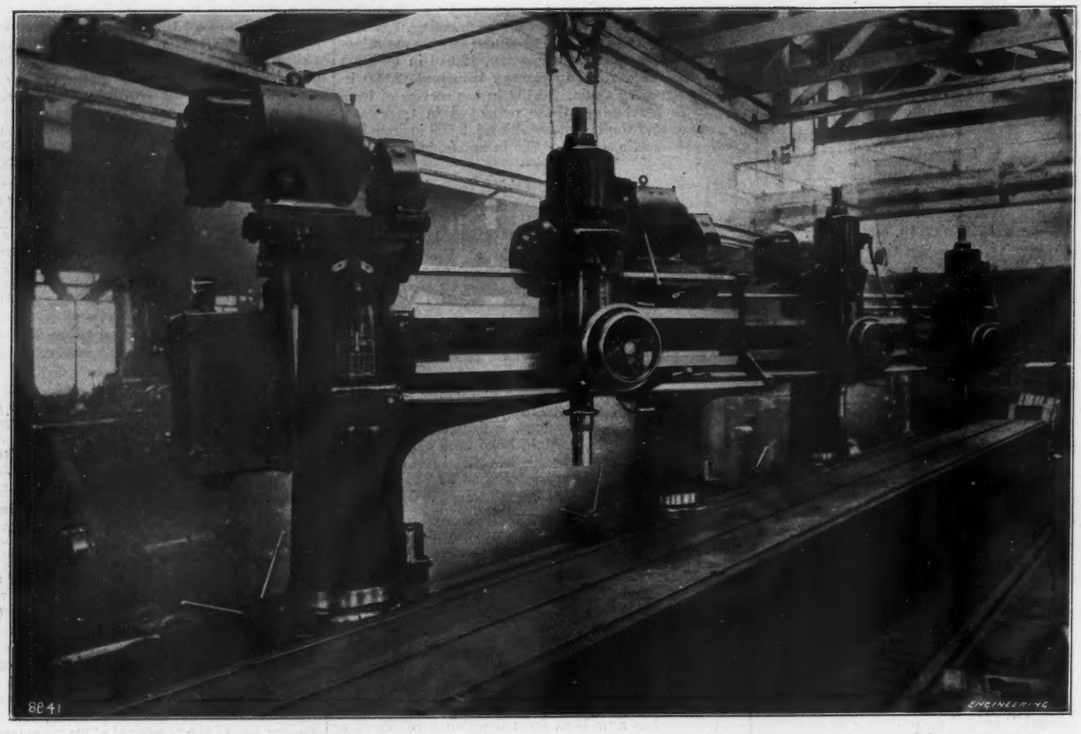
Dr. Myers explained that, so far as concerns the human factor, the Institute's experience was that deficient output was due to conflict between the worker and his environment, even when it appeared to involve conscious wilful restriction. Its experience was that Labour is extremely interested in the Institute's methods, realising that those methods aim, not at directly speeding up the worker, but at removing such needless friction as prevents him from giving his best. In no case had objection been raised by any trade union to the investigations; on the contrary, in several factories the works committees had given active co-operative in them, even suggesting an extension of the Institute's work in other directions.

The modern need in large works, Dr. Myers submitted, was the establishment of a department of persons specially trained in industrial psychology, which should be at least of equal rank to those of engineering and finance. This need arose from the fact that the manager was, as a rule, now too closely occupied in technical and commercial details to be aware of the difficulties and obstacles which beset the worker at his work, or to be readily accessible and responsive to him; while the foreman was chosen primarily because of his ability as a craftsman or because of his knowledge of machinery, rather than for his capacity to comprehend and to improve the human factor. His duties were becoming increasingly executive; he was usually expert in dealing with mechanical defects, but he might lack the temperament, the knowledge and training—indeed, he might not be given the necessary liberty—to diagnose and to remedy, as they occurred, the many obstacles of a psycho-physiological character which prevented the worker from producing his best.

In a written reply to a question by Major Glyn, Sir Arthur Steel-Maitland states that the total expenses of the International Labour Office at Geneva from its establishment in 1919 to December, 1924, amounted to about 33,454,188 Swiss francs. The British Government's contribution towards these expenses during the same period amounted to about 2,692,000 Swiss francs, or about 117,780*l*. in sterling. The salaries of the British Government delegates are borne on the Votes of the Departments to which they are attached. No remuneration is paid to non-Government delegates. At the annual conferences the expenses of non-Government delegates and of their advisers are paid by the

THREE-HEAD RADIAL-DRILLING MACHINE.

CONSTRUCTED BY MESSRS. CROSSLEY AND CO., ENGINEERS, MANCHESTER.



British Government on a scale approved by the Treasury. At meetings of the governing body the non-Government members receive payment of their expenses from the International Labour Office.

Speaking at Barrow on February 24, after the launch by Vickers Limited, of the new Cunarder Carinthia, Sir Vincent Caillard said that a prominent man in the shipping industry had expressed a hope that directors and workpeople engaged in shipbuilding would stop fooling, or there would soon be no business to fool about. He highly appreciated that good advice. At Barrow, he was glad to say, there was between Commander Craven, director of the works, and his staff on the one side, and their very fine body of workpeople on the other, a gratifying condition of friendly understanding. Exceptions to such a state were, however, found all over the country. The red tail of Communism was attempting to wag a very big dog. Personally, he had profound faith in the sound commonsense and cool judgment of the great body of British workpeople, and he had no fear of the ultimate outcome. The little red tail would some day, perhaps not far off, get its final quietus.

Commander Craven, who also spoke, said that the wages spent in Barrow works alone, on a ship like the Carinthia, exceeded 300,000*l*. Prices ruling to-day for merchant ships did not enable the builder to cover the overhead charges directly attributable to any contract, and the balance had to be brought from reserve funds. If the recommendations of the proposed new Committee on Naval Construction referred to a programme extending over the life of the present Government, he felt sure the stability which would be given to the shipbuilding industry would amply compensate for the few months' delay in the placing of the orders.

After Wednesday's meeting at Blackpool of the executive committee of the Miners' Federation of Great Britain, Mr. A. J. Cook, the Secretary, stated that he had been instructed by the committee to make arrangements to meet the executives of four other organisations as quickly as possible, in order to discuss with them the possibilities of mutual help in wages disputes. There is to be a preliminary meeting in London, probably next week, prior to the meeting of the General Council of the Trades Union Congress. The organisations which are being approached are the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, the Transport Workers' Federation, and the Amalgamated Engineering Union.

THREE-HEAD RADIAL-DRILLING MACHINE.

The machine which is shown in the accompanying illustration is a good example of modern practice in the construction of multiple-headed drills and, with another of the same design, was recently supplied by Messrs. Crossley and Co., of 6, St. Mary's-gate, Manchester, to the South African Government. The requirements specified by the purchasers were that the machines should be capable of dealing with work on a surface 40 ft. long and 2 ft. 6 in. wide. To meet this demand, three heads were fitted to the machine, all arranged for independent adjustment along the bed and with drill spindles which can be moved along the radial arms to work between a minimum radius of 1 ft. 4 in. and a maximum one of 5 ft. 3 in. As will be understood from the illustration, separate motor drives are provided for each of the three heads.

At the back of the machine, the drill heads are mounted on a substantial bed, which is 2 ft. 6 in. wide and 1 ft. 3 in. deep. On this, the heads can be moved along by means of a steel rack and pinions, operated by means of star handles. Between the sliding bases and the bed, ball-bearing rollers are provided to make the movement as easy of accomplishment as possible, and once the heads are moved into suitable positions for the work to be done, they may be effectively locked prior to the commencement of drilling operations. Swinging through a complete circle of each radial arm is arranged for, and to retain any of the arms in the desired positions there are suitable locking mechanisms. The table is of ample size to accommodate work of the maximum dimensions to be dealt with, and it has three T-slots to facilitate the retaining of the job in position.

Each head is driven by a separate electric motor of 7½ h.p., through reduction gearing and a four-speed gear-box. As there is a double gear provided, eight spindle speeds may be obtained, ranging from 400 r.p.m. to 32 r.p.m. The spindles have a vertical travel of 15 in., are 2¼ in. in diameter and are bored No. 4 Morse taper. Thrust is taken up on ball thrust washers, and compensating spring mechanisms are introduced to balance the dead weight. For positive feed, four rates are obtainable, ranging from 40 cuts to 120 cuts per inch, while fine and quick spindle adjustment by hand is a feature of the machine. A positive clutch, incorporated in the drive, serves to ensure satisfactory action in starting and stopping. From the illustration it will be appreciated that the reverse and double gear motions are placed in suitable positions for convenient control by the operator.

Personal.—We understand that the Featherstone Hammond Partners, Limited, 28, Victoria-street, Westminster, London, S.W.1, will deal with all negotiations connected with the supply and installation of "Brumler" boilers.—The Foster Engineering Company, Limited, electrical and mechanical engineers, Morden Works, Wimbledon, London, S.W.19, have appointed Mr. F. Routledge, of 21, Temple-lane, Dublin, as agent for the sale of their products in Ireland.—The Premier Electric Welding Company, Limited, managed solely by Nobels Industries, Limited, has decided to discontinue carrying on business from their Swansea establishment. Arrangements have been made, at the same time, for extending the facilities at the Abbey Wood factory, London, S.E.2, for the manufacture of "Premier" electric arc-welding plant.

Boiling Points and Vapour Pressures of Solid and Liquid Metals.—Most determinations of the vapour pressures (v.p.) of metals have been made at atmospheric pressures. R. W. Millar, of the United States Bureau of Mines, recently deduced a formula by means of which the v.p. at any temperature can be calculated from a single determination of the v.p. of the liquid or solid metal at one temperature. He finds the following boiling points of liquid metals, expressed in deg. C absolute, at pressures of 760, 300, 50, 1, and 0·1 mm. of mercury:—Cadmium 766, 686, 565, 386, 321; magnesium 1,120, 1,015, 855, 615, 515; aluminium, 1,800, 1,635, 1,390, 1,030, 885; manganese 1,900, 1,720, 1,465, 1,080, 925; copper 2,310, 2,120, 1,825, 1,400, 1,220. In all these cases the one boiling point determination had been made at atmospheric pressure. In the case of nickel, cobalt, and iron, the ordinary boiling point (at one atmosphere) had been calculated from a boiling point determination at a pressure of 36 mm., and the corresponding figures for iron would be 3,235, 2,930, 2,520, 1,900, 1,655. The figure assumed for the ordinary boiling point of iron, 3,235 deg. C., seems high, and is considerably above the only other value observed—that of Greenwood, 2,450—which was, however, undoubtedly too low. In general, the difference between melting point and boiling point increases as the former rises; platinum, melting at 1,607 deg. C. absolute, is from other considerations supposed to boil at 3,707 deg. C. Millar's vapour pressures of solid aluminium at 25, 300, and 659 deg. C., the melting point, (not on the absolute scale) are 7×10^{-29}, $3 \cdot 4 \times 10^{-11}$, and 0·00062. Higher figures are found for the solid metals cadmium, magnesium, copper which, at their melting points of 321, 651, and 1,083 deg. C., have vapour pressures of 0·098, 2·28, and 0·012.

INSTRUMENT FOR RECORDING VIBRATIONS.

CONSTRUCTED BY THE CAMBRIDGE INSTRUMENT COMPANY, LIMITED, LONDON.

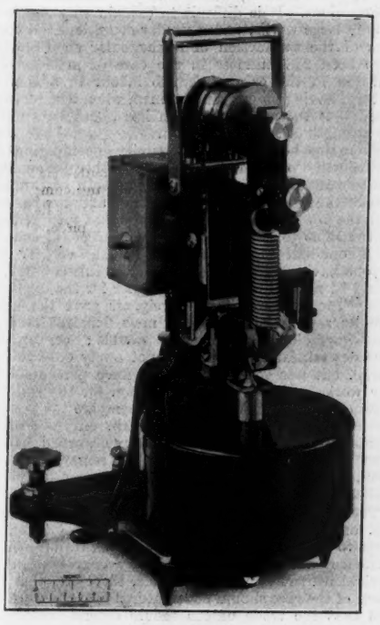


FIG. 1.

FIG. 3. RECORD OF FLOOR VIBRATIONS NEAR SMALL AIR COMPRESSOR.

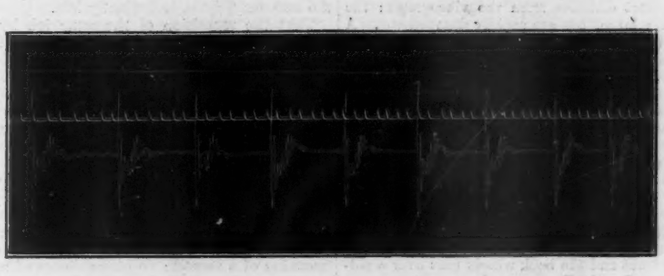
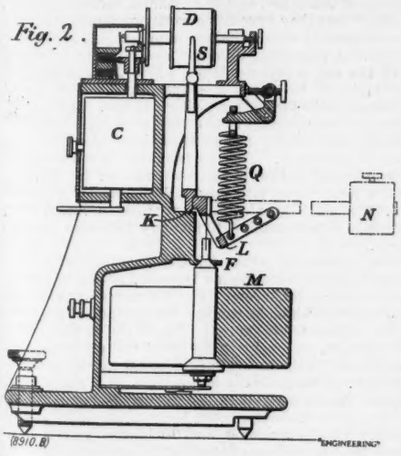


FIG. 4. EFFECT OF A REGULAR SERIES OF BLOWS ON UPPER FLOOR OF BUILDING.

FIG. 5. VIBRATIONS OF CHASSIS OF COMMERCIAL VEHICLE.



THE CAMBRIDGE VIBROGRAPH.

THE Cambridge vibrograph, which we illustrate in Figs. 1 and 2, on this page is a small robust form of seismograph designed and constructed by the Cambridge Instrument Company, Limited, 45, Grosvenor-place, London, S.W. 1, for measuring vibrations of the ground and of buildings, bridges and other structures. Permanent records, such as are exemplified by the photographs reproduced in Figs. 3 to 5, are obtained by marking on celluloid, a method which Mr. W. G. Collins, a member of the firm, first adopted in the Cambridge micro-indicator for high-speed engines, described on page 716 of our issue of June 9, 1922.

The vibrograph illustrated in Fig. 1 records vertical movements of ordinary amplitudes. If required for violent oscillations, the instrument is fitted with the steelyard attachment indicated by the dotted lines of the sectional diagram, Fig. 2. We shall first describe the former type. The instrument comprises a weighted lever, pivoted upon knife edges on a stand which, when placed on the structure or ground, partakes of its vibrations. The small lever movements caused by the vibrations are recorded upon a moving strip of celluloid by a fine style carried at the extremity of an arm joined to the lever. The heavy mass used is a weight M of 16 lb., which is supported upon a vertical pillar attached at the top by a metal strip to a steel block which is pivoted to the stand by means of the knife edges K. The steel block forms a short lever, the effective length of which is equal to the horizontal distance between the strip and the knife edges. The weight M is slotted from its edge to the centre so that it can be readily placed on the pillar or removed and is centred by a conical recess at the bottom of the slot fitting on to a conical base formed on the pillar; a spring plunger near the top of the slot helps to retain the weight in position. The vertical pillar itself is supported from below by a thin horizontal flat spring which confines the relative movements between the weight and the instrument to the vertical plane. By the aid of a heavier flat spring and a system of wedges immediately below the other spring, the weight can be clamped for transit. The inertia mass of the weight is further balanced by a helical spring Q suspended from the upper portion of the stand. The lower end of this spring is hooked into one of the four holes in the arm of the bell crank lever L, and by selecting one of these holes the period of the moving system can be altered if resonance troubles between the vibrations to be measured and the natural period of the instrument should occur.

An arm extending upward from the pivoted steel block, previously referred to, has at its upper extremity a flat spring S, carrying the recording style. This style bears upon the surface of a celluloid film (actually a portion of clear kinematograph film) wrapped round the split drum D which is rotated by means of the clockwork mechanism C. The pressure of the style against the film is adjusted by turning a small milled-head screw. An eccentric rod situated immediately behind the spring carrying the style can be turned by a small lever so as to raise the style out of contact with the film and so protect the point of the style when the film is being removed. The upper end of the helical spring Q is supported on a bell-crank lever hinged to the stand and is adjusted by a screw. By turning this screw, the tension of the spring can be modified so as to raise or lower the crank L, thus pivoting the steel block upon the knife edges and adjusting the zero position of the style. By means of an adjustable governor of novel design controlling the clock-work mechanism, the speed of the film can be varied between about 4 mm. and 20 mm. per second. In the narrow gap between the two portions of the split drum D rests a second style which can be shifted laterally by means of an electromagnet acting through a small lever mechanism inside the drum. This electromagnet is connected to a separate clock, making contact every tenth of a second, or other time interval. Thus a zero line with time markings is recorded on the back of the film simultaneously with the actual "vibrogram" on the front.

When vibrations of considerable amplitude are to be recorded, a double purpose instrument is supplied, in which the heavy weight M can be removed and replaced by the arm, already mentioned, on which the weight N is carried. When in position this arm extends horizontally, and the leverage is such that the pressure on the knife-edge K of the steel block is upward, and not downward as in the former case. For this reason the steel block is provided with two pairs of knife edges in line, the outer pair directed upward and the inner pair downward. When the weight N is used, the outer pair of knife edges is brought into action. The horizontal attachment enables unmagnified records to be obtained as well as records reduced between the ratios 1 : 1 and 1 : 2. The adjustment of the weight N is of particular utility when vibrations are measured which approach the natural period of the instrument; by

moving the weight, this period can be varied from about 0·5 to 1 vibration per second.

The records obtained can be read by a microscope accurately to 0·01 mm., or they can be projected optically and as the initial magnification of the recording instrument is 10, a total magnification of 500 diameters can easily be obtained by the aid of an adjustable microscope supplied by the firm for this purpose, or by other means. With such a magnification, a vertical movement of the ground of 10^{-4} cm. is clearly measurable. The records are immediately available for examination; they are permanent and durable, and are not injured by dust or moisture. Owing to the optical characteristics of the form of indentation made on the film by the style, each magnified record appears as a fine black line flanked by two white lines; but our reproductions of actual records show that this feature does not impair the distinctness of the curves at all, it rather increases the accuracy with which measurements can be taken. In our illustrations the actual vibrations are magnified about 100 diameters; the time interval marked is $\frac{1}{10}$ sec. in all cases. In Fig. 3 are illustrated the vibrations of a concrete floor on which a small air compressor was in operation. Fig. 4 shows the vibrations of the upper floor of a building when subjected to a regular series of blows at a short distance from the vibrograph; the oscillations are large, but are rapidly damped out. A small electric motor working on a bench yielded a series of small and, on the whole, very regular vibrogram curves. When the vibrograph was mounted upon the chassis of a commercial motor vehicle, which was kept stationary while the engine was running, the vibrogram showed oscillations of fairly uniform appearance, although when the engine was run at different speeds, bad resonances were set up as the frequency of the engine vibrations approached that of the springs and other parts; four or more periodicities can be distinguished in the vibrogram of Fig. 5. Other vibrograms taken, but not reproduced here, bring out the differences in the vibrations set up on a motor-car when the front and the back wheels pass over a pot-hole in the road; the back wheel causes the larger vibrations. Similar vibrograms clearly indicate the advantages of pneumatic tyres over solid tyres in reducing the vibrations caused by running over rough roads.

SKILL IN RELATION TO PRODUCTION.*

By L. A. Legros, M.I.Mech.E.

(*Concluded from page* 224.)

Too little has been said about the "black hand" in ndustry, its veiled threats, and the awe in which the worker stands of his "society." The apprentice who works too fast is cautioned that he should be more careful because accidents sometimes happen to people who do not look after themselves sufficiently; if no notice is taken, some disarrangement of his machine of an inexplicable kind takes place during a momentary absence from its vicinity; and if this hint does not suffice, the next warning actually takes the form of some other disarrangement that either spoils his job or damages the machine itself as well. Too much could not easily be written on the subject of this hidden influence, generally inspired by hatred of the employer class and encouraged by a great fear of the other members of the trade union; it has been one of the principal factors in producing the *esprit de corps* shown by the workers when on strike, and it appears to those who know anything of the inner workings of movements of unrest, to produce more permanent fear by the hint that there will be no future chance of employment than that due to the so-called "peaceful picketing."

For physical qualities we have standards or measures that are portable, such as the foot or the metre rule, the watch or chronometer, and the pound or kilogramme, by means of which we can re-establish standards elsewhere. But there is nothing like the rule, the balance, or the stop-watch that can be applied to most varieties of human work. It is the absence of a standard that assists the trade unions to allow the rate of production to be kept down, and gives the agitator a chance to disturb the balance between employer and employed.

There are, however, other and more insidious methods by which the agitator can get to work, and one of the easiest fields in which to sow discord and disaffection is the repair shop. The repair worker is usually a man having skill and also required to use reasoning power. He has to carry out work at inconvenient hours, sometimes under unpleasant conditions, and often against time. It is a common occurrence in almost all repair shops that "runs" occur of machines, locomotives, or even ships, becoming disabled simultaneously; and by a perversity of Nature, such things may happen near a holiday or a cup-tie or other interesting event. All of this can be, and usually is, put down by the agitator to bad management or malice of the management.

The conditions under which a really highly skilled toolmaker or tradesman works, on jobs in which a slight error in any movement of the hand in tedious lapping operations would spoil the job, produce a nervousness that is very real and not appreciated generally by the employer or by the less skilled or the unskilled worker. In working to limits of a twenty-thousandth of an inch* many of the best workers have admitted that when a director or a stranger visited the shops they substituted a "dud" or waster for the piece they were apparently finishing, and would only proceed with the proper piece after the disturbing influence had removed itself. This appears to be due to the work being up to the limit attainable by hand; it is a form of nervousness that is common to many artists, and the best precaution is to keep strangers away. To these men, the repetition of parts is more trying than variety, because they have inevitably to use the same muscles in the same way. Where the limits are easier, and there is some variety in the parts, the nervous tension is distinctly less.

That the repetition of the same job by the same muscles at short intervals should cause fatigue has long been recognised, and the trend of the development of machine design has been towards the performance by power of heavy operations, and those which follow a definite sequence, leaving the minor operations of starting, stopping, and feeding to comparatively light hand or foot controls. The more nearly automatic a machine becomes, the less is the amount of physical work done by the worker, and the more is his task reduced to watching, by eye and ear. In the textile industries, in spinning and weaving, continuous watching by eye is necessary, except in those machines which stop automatically on the breaking of a thread; in other classes of machine the watching is largely performed by ear.

There can undoubtedly be monotony in repeated operations that produce fatigue, but the causes of fatigue are sometimes not easily explained. A man has been known to give up a job at printing tickets because he had to watch too many colours in the day. Some men became fascinated by moving parts of machines, and try to dodge the moving parts, risking their fingers, whereas others are little, if at all, affected under ordinary conditions, but cases have been known of passengers throwing themselves into the crank-pit of a marine engine. A traction engine, which had wheels so large that they reached above the head of the driver, with the result that the spokes passed his eye in the same direction as the motion of the vehicle, had a kind of hypnotic effect on the men who drove it. Holding handles of machines or tools tightly for long periods has been found to produce a permanent contraction of the muscles of the hand.†

The modern artisan works by sequences of operations, using thought as little as possible. Once the principle has been realised that this is at the same time the easiest and quickest way of working, the idea of monotony disappears and forty years' experience of several trades and several thousand workers has, apart from genuine fatigue due to exacting conditions on highly skilled work, only brought to light one or two cases amongst managers, engineers, workers, and apprentices, and these were amongst those who commenced their apprenticeship late. If there is any great measure of truth in the outcry against the monotony of repetition work, it is strange that work of this kind in factories should be so much preferred to domestic service in this country, and still more remarkable that this preference should be even stronger under the more stringent conditions prevalent in the United States, where repetition is studied, down to the elimination of all unnecessary movements.

For several years the trade unions have been levelling the wages of the lower grades of skill up, and incidentally levelling the higher grades down, by increased restriction on the range of work that their members are permitted to perform. If a hole is required to be drilled, it must be done by a driller, who must not use a file; each job is required to be handled by as many different men as there are "recognised" trades involved, with resultant slowing down. One of our greatest mechanics, Nasmyth, realising the danger, expressed his belief "that free trade in ability has a much closer relation to national prosperity than even free trade in commodities."‡

Much has been said of the possibilities of mass production. It can be made a success in America, where skilled labour is far more highly paid than it is in this country. War work showed its possibilities where quantities were really large, but it also revealed the opposition to it, which was not confined to the trade unions. It is difficult to explain why the best time in large works, under similar conditions, on long runs of the production of a particular shell should have been 248 minutes in the case of male labour and 128 in the case of female labour in a similar factory, having 95 per cent. women, when it is remembered that the average woman has about two-thirds the strength of an average man.

There was, however, an opportunity of comparing the British with Continental workers of another nationality, and this afforded a rather surprising result. Examination of the wages and piece-drawings and comparison with the jobs in various shops showed that the foreigner on the same job at the same price per piece, usually made one-half more than the British worker. To anyone having experience of labour in this country, it would be natural to ask the foreigner for the explanation. The answers of the foreigners gave the key: "Si les associations ouvrières nous fichaient la paix nous gagnerions facilement le double; ces anglais sont des fainéants." This did not apply only to one works, but was general as to the fixed percentage in any works and also as to the reason for the ratio of productivity. It is interesting to compare the present conditions with those of 1840 when, on the French Western Railway, the English navvy worked harder than the French, and provoked the remark: "Mon Dieu, voilá! Voilá ces anglais, comme ils travaillent."*

The learned professions, the Church, the law, teaching, and—at a later period—medicine, took various steps to secure their rights, by requiring training or its evidence in the form of university degrees or their equivalent. It is not remarkable, therefore, that the spirit of the race should have entered into the workers, and that the trade unions should defend what each regards as its own particular field of labour. When the water-tube boiler came into extensive use, the boiler-makers claimed, as a right, to do the turning and screw-cutting of the tubes, and in an almost incredibly short space of time they were doing work previously regarded as falling solely within the special province of the skilled turner. A somewhat different case is that of cutting with the oxy-acetylene flame, where 20 men were to be employed to watch a couple do the work by a different method from that hitherto in use. Objection is even now being raised to one man working a multiple-spindle drill on the ground that there should be one man for each drill. The war taught us much as to the provinces mapped out by the trade unions; for instance, that a No. 9 turret lathe was a skilled man's job and a No. 8 a semi-skilled job. One had to look rather carefully at the machines to find any difference between them.

The apprentice works for five years or more at a trade for a lower wage than he would obtain on repetition work or labouring. The difference between his pay and that which he would have obtained at unskilled work represents his capital. Now if the skilled man is a capitalist, we ought to find that the more highly a man is skilled the higher should be the market value of his skill. This generally is not the case. The pattern maker, usually a highly skilled worker, gets two shillings a week or thereabouts, extra, to cover the upkeep of his tools. The gaugemaker and toolmaker gets a little more than an ordinary fitter, but very little compared with the difference in skill, the time spent in training, and the exacting character of the work. Next to the slowing down of work, which operates slowly by yielding markets to those who give better value for an equal sum of money, an effect which is masked by the inevitable fluctuation in trade, will come the failure to produce skill in adequate quantity, not merely because the capital investment is inadequately rewarded, but because the earnings of the unskilled are actually much higher in some of the sheltered trades. Why be a skilled mechanic and earn 56*s.* a week in a competitive trade when the protected dustman may get 80*s.*?

Those industries that are local in character have not felt the direct effect of a foreign competition to which they have not been exposed, and have been able to enforce a rise in wages above what they obtained during the war. The result has been a complete disturbance of the balance as previously recognised, and, so far from a levelling down to equality, the wages in numerous branches of unskilled work have risen far above those of the skilled. The skilled men, the aristocracy of labour, who recognised the fact that men engaged in trade, though devoid of skill, might earn more, but had not their rank, are now the new poor amongst the workers. The workers in the building trades are an

* Presidential Address delivered to the British Section of the Société des Ingénieurs Civils de France, on Wednesday, February 18, 1925. Abridged.

* The Wicks Rotary Typecaster, in which each mould-wheel required 200 segments lapped to this limit of accuracy on two faces inclined to each other at an angle of 3° 36'.

† Dupuytren's contractions occuring in lace-making machine workers.

‡ James Nasmyth: an Autobiography, 1883; page 218.

* Smiles' Lives of George and Robert Stephenson (1870), page 252.

exception, their skill not being exposed to foreign competition, with the double result that pay has increased and output has diminished. The sheltered trades are numerous; they comprise the transport trades, the carriers by railway, tramway, and road, which form a very large group; the dock and warehouse workers in the ports; the electrical supply workers, gas and water supply, and municipal services, including dustmen and scavengers.

The past history of trade unions has shown that when, as in the present case in the building trade, the combination of high price with low output reaches a limit, the engineer either by invention or by adopting other methods, is forced to find a remedy, as happened in the coopers' trade, and has happened in many branches of other trades as soon as the pressure for supply has become acute, whether on account of the cost, or of the time required for manufacture, or both combined.

The difficulty that will have to be faced when the exports, the carrying trades, and foreign investments, no longer pay for the imports, will bring the question of "Free trade in commodities or Free Trade in ability" to the light of day. The coal trade cannot be counted as a sheltered industry; oil is ousting coal from many uses, and oil adds to our imports; at present we have in general use no means of obtaining a liquid fuel from coal commercially, or of producing a smokeless fuel that can compete with anthracite.

While the skilled man is paid less than the semi-skilled or the sheltered unskilled, the incentive to apprenticeship and manual education ceases to exist, and when, as frequently happens, there is unfair cutting of piece rates, the incentive to semi-skilled labour also diminishes. Both had gone so far before the war that very many of our large works were riddled with "cells" and "rays" diffusing militant socialistic propaganda, and the outcry in the workshops was great not to worry about the war in Europe, but "to get on with the war that really mattered." The soil on which these poisonous plants grow is only too easily fertilized by unfair treatment of the piece-rate question, by reducing rates for the same part made under another order, and by cutting the rates to an extent that affords the employee no chance to make a wage sufficiently large to recompense the harder effort exerted.

Employers who adopt these tactics compete unfairly with others, and it is the other employers who, suffering from the competition of cut prices for the product, should deal with them. This is fairly obvious in the case of the employers, but it is equally necessary that the holding back of output and the general slowing of industry should be stopped by the action of the trade unions, for trade is more easily driven into other hands than recovered.

If British labour wishes to know how far the workers in other countries are really in sympathy with restriction of output, reduction in hours, and increase in pay, it would impress the manufacturers and the public far more to have figures and facts obtained by independent authorities; or failing these, by a small joint committee of equal numbers of representatives of employers and employees, care being taken that of the employers' quota, each should have received the manual education of a skilled man; and that the representatives of the employees should not be selected merely for their popularity, but for known qualities, such as ability to understand statistics, to appreciate the weight of evidence, and to be fearless in speaking the truth even when it is unpleasant.

The business man who employs an expert wants the truth, whether it is pleasant or otherwise, so that he may know whether to proceed or to cut his losses. Those who have undertaken such tests and reports appreciate that the psychological side must count for nothing, that facts are the essential, and it is important to ascertain that materials and conditions are such as can be readily obtained or repeated. But is it the same when the representatives of a trade union visit a foreign country? Are they at the mercy of a foreign guide and a foreign interpreter, or do they lay down a programme for inspection, and examine the seamy side of affairs also?

It has been an insular habit to consider British work and British labour as the finest in the world, but it is a dangerous belief as soon as it ceases to be true. The tests of cost, correctness in quality, and time of delivery are those on which the future of industry depends; and, though manufactured goods may be produced with less skilled and more semi-skilled and unskilled labour, it will, nevertheless, be necessary, for the construction of the means and the control of the product, that the nation should produce and retain a sufficiency of highly skilled labour. The risk of skill falling below the requisite amount and quality is very great, and the danger commenced to be realised during the war.

Among the new industries that, springing up just before the war, required to be brought rapidly into production on a large scale, one that presented many of the most troublesome difficulties, was that of aircraft. Thus, the assembling of an aeroplane required three types of erector: the first for assembling the fuselage and wings, the second for assembling the engine with its accessories in the fuselage, and the third for assembling and adjusting the controls. For the first, men could be found from amongst joiners and cabinet-makers; for the second, engineer erectors and men from the automobile shops; but for the third type, men were required who could work in wood as well as in sheet metal, and who could arrange control leads so as to work smoothly. For this class it was necessary to get men from other trades, and the organ-builder, possessing the general skill and requiring little further specialised training, proved himself very adaptable. The propeller was apparently the job for the pattern-maker, but too many propellers were required for the pattern-makers available, and the furniture makers had to be drawn upon to produce them, which they did at much higher speed than the pattern-makers.

The simplification of manufacturing operations and the substitution of mechanical for manual power have enabled the demand for skill to be reduced, and at the same time enabled large numbers of workers to retain employment, who, under harder conditions, would have been unable to earn their bread.

The universal slowing down of work, though for the time it provides employment for a greater number in skilled trades, will not merely drive capital, but the capitalists as well from the country.

The only alternative to this decay in trade, and general exodus, that shows a possibility of the restoration of industry to a sound basis lies with the trade unions, many of whose officials should examine the questions that relate to production and foreign trade a great deal more thoroughly and open-mindedly than they have examined Socialism and communism. If they can establish a secret voting system equivalent to that adopted in Parliamentary elections, a gradation of skill whereby men capable of working at several trades and carrying a job through, can be permitted to earn higher wages than the unskilled of sheltered industries; in fact, if they can put into order a house that is in serious danger of collapse—then, with skill a free factor in education for all, and the qualification of tradesmen by independent judges, there may be real hope of industrial peace.

INDUSTRIAL WELFARE SOCIETY.—The sixth annual report of the Industrial Welfare Society for the year ending June 30, 1924, has now been published. A full account is given of the recent activities and affairs of the society. The Duke of York's Camp for Working Boys was again held during the year under review, and proved highly successful. The subject of accident prevention received special attention, a brochure constituting a practical guide and handbook being issued during the year.

THE INSTITUTE OF METALS.—The annual general meeting of the Institute of Metals will be held in the Hall of the Institution of Mechanical Engineers at Storey's Gate, Westminster, London, S.W.1, on Wednesday and Thursday, March 11 and 12. During the proceedings some thirteen papers are expected to be submitted, of widely varied interest. These include contributions from Messrs. H. T. Angus and P. F. Summers, on "The Effect of Grain Size Upon Hardness and Annealing Temperature"; from Mr. S. L. Archbutt on "A Method of Improving the Properties of Aluminium Alloy Castings"; and from Messrs. G. L. Bailey and R. Genders on "The Density and Constitution of the Industrial Brasses." "Comparative Tests on Some Varieties of Commercial Copper Rod," by Mr. T. G. Bamford; "The Removal of Red Stains from Brass," by Mr. E. A. Bolton; and "The Influence of Lead and Tin on the Brittle Ranges of Brass," by Mr. Denis Bunting. "Surface Abrasion as a Potential Cause of Localised Corrosion," by Mr. Ulick R. Evans and "The Influence of Emulsoids upon the Rate of Dissolution of Zinc in Solutions of Lead, Nickel, and Copper Salts," by Dr. J. Newton Friend and Mr. J. S. Tidmus are of more scientific interest. One on "The Alpha Phase Boundary in the Copper-Zinc System," is to be read by Messrs. R. Genders and G. L. Bailey. Professors Honda and Yamada will present a contribution entitled "Some Experiments on the Abrasion of Metals." Mr. A. L. Norbury will provide a "Note on the Effects of Certain Elements on the Electrical Resistivity of Copper. Other monographs to be read are entitled: "On the Density of Rhodium" and "On the Equilibrium of the Aluminium-Zinc System," the first compiled by Professor T. Isihara, and the second by Sir Thomas Kirke Rose. This year the Annual May Lecture, to be given on the sixth of the month, will be delivered by Professor H. A. Lorentz, of Leiden, Holland, and will consist of a discourse on "The Motion of Electricity in Metals." The Annual Dinner of the Institute of Metals will be held at the Trocadero Restaurant, Piccadilly Circus, London, W.1, on Wednesday, March 11. Further particulars relating to the arrangements for the meeting may be had from the Secretary, The Institute of Metals, 36, Victoria-street, Westminster, London, S.W.1.

COMPACTING MACHINE FOR SAND-CEMENT BRIQUETTES FOR TESTING.

THE machine about to be described was designed for compacting automatically the sand-cement briquettes used in testing the tensile strength of cement. It has been in constant use for testing cement to the Argentine Government's Specification in the Imperial Institute cement department for some years past, with satisfactoryr esults. Before entering upon the description proper, it may be of interest to narrate briefly the circumstances in which it came to be designed and constructed.

In 1914, the Argentine Government introduced a new Specification for Portland cement, which required that cement used for public works in that country must be guaranteed by a certificate issued by the Argentine Government or "by the laboratories and testing departments controlled by the Ministry or Government Public Works Department of the country in which the cement is manufactured." In order to enable British cement manufacturers to comply with this provision of the specification, the Board of Trade in 1915 arranged that testing and certifying should be carried out by the Imperial Institute, and since that date a large number of consignments for export to the Argentine have been tested.

The Argentine Government specification requires the use of certain appliances which are not necessary when testing cement to other specifications, and it became evident that in order to perform the tests expeditiously and satisfactorily, special apparatus would be essential. One urgent requirement was a means for compacting the sand-cement briquettes to comply with Article XII. of the specification which states that "The moulds shall be prepared . . . by filling six (6) at a time with a quantity of mortar in excess of their capacity. This shall be pressed into the moulds by means of an apparatus in which a hammer weighing 2 kilograms falls one hundred and twenty (120) times consecutively from a height of forty (40) centimetres." The specification further requires that a minimum of five samples from each consignment shall be taken for physical tests, and this involves the moulding of sixty sand-cement briquettes each compacted in the above-described manner, necessitating over 7,000 blows. The ordinary short-armed Boehme hammer machine described in the German Government specification for Portland cement, does not comply with the requirements of the Argentine Government specification, as the fall of the hammer of the German machine is only 20 cm. Moreover, such machines usually carry only two or three hammers, and hence in order to carry out the Argentine requirements, two or more machines must be used simultaneously.

It was evident that the time occupied in gauging, compacting, and finishing the sixty briquettes would be excessive when using such hammer machines, and the provision of a machine which would compact all six briquettes automatically in one operation was, therefore, necessary. A power-driven machine was accordingly designed by Mr. A. T. Faircloth, and constructed in the Imperial Institute workshops. The machine is in constant use and fulfils its object very satisfactorily, and as it embodies some interesting mechanical details, a description of its construction may be of service to those engaged in cement testing. It is designed upon the principle of a pile driver stopping automatically after 120 blows have been delivered and in this respect resembles the Klebe hammer.

In the Imperial Institute machine, shown in Figs. 1 to 5, on pages 274 and 275, the method adopted for raising the six 2 kg. hammers is by means of endless roller chains, each of 78 links, passing over two sets of six small sprocket wheels, each of 1·9 in. pitch circle diameter and having 12 teeth. Six of the wheels are fixed rigidly by means of set screws to the driving shaft which runs along the top of the machine, the remaining six being attached to a second shaft running directly beneath it.

In each of the six chains one of the bolts has been replaced by a roller pin which projects about half an inch on each side of the chain, and engages with a forked projection attached to the top of each hammer; by this means each hammer is raised until the roller-pin starts its downward journey over the top sprocket wheel, when it disengages from the fork and releases the hammer which drops on the die beneath. This process is repeated, the six hammers dropping in pairs, i.e., first Nos. 3 and 6, next Nos. 1 and 4 and lastly Nos. 2 and 5. The weight of only four of the hammers is thrown momentarily upon the shaft, as during the greater part of the time only two are being raised.

Any slackness which may develop in the chains is taken up by means of tighteners fixed at the back of the machine and acting on the descending side of each chain. One of these is shown in Fig. 5. They are held in contact with the chains by small springs, and in order that each may act without affecting the remainder, a shallow groove has been cut in the lower

COMPACTING MACHINE FOR SAND-CEMENT BRIQUETTES FOR TESTING.

Fig. 1.

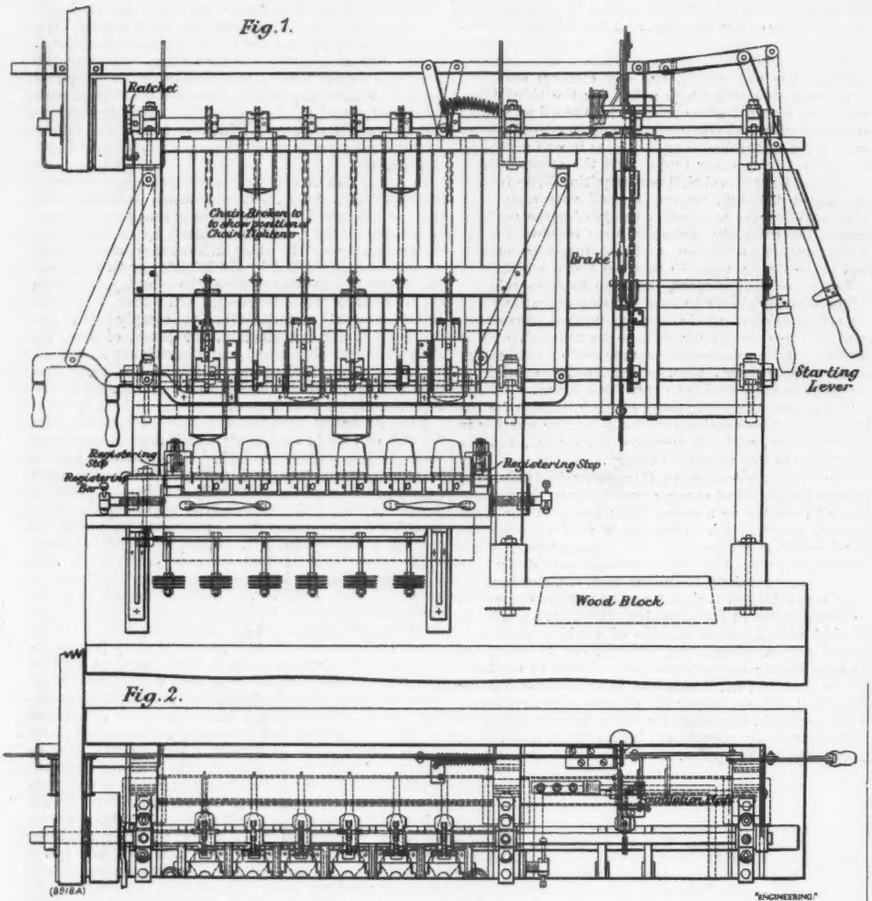
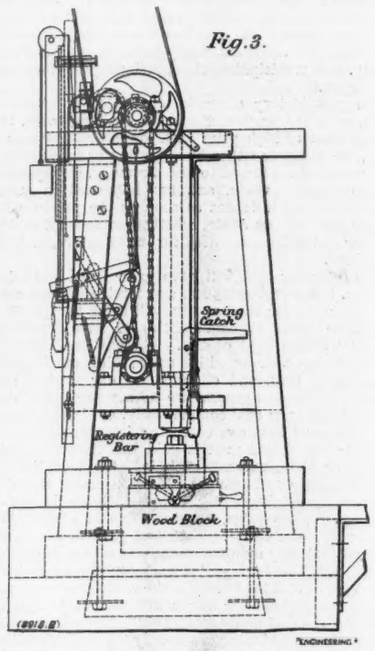


Fig. 2.

Fig. 3.



shaft at right angles to its length, so that the set screws by which the spur wheels are attached to this shaft are allowed a little play as shown in detail in Fig. 5.

The Argentine Government Specification requires the number of blows on the die to be 120, and it was necessary to throw the hammers out of action immediately this number of blows had been delivered. This is accomplished by the following arrangement. At the extreme right of the machine is a seventh chain (Figs. 1 and 5) also fitted with a projecting roller pin which occupies the same relative position as those pins in chains Nos. 2 and 5. This chain is used primarily to work the counting and striking gear, this being accomplished by its roller pin engaging with a ten-toothed spur wheel best seen in Fig. 5 at A. This is moved forward one pitch at each revolution of the chain, that is after each of the hammers has delivered one blow. Provision has been made so that the seventh chain in conjunction with an extra hammer can be used for compressing the mixture into cubes if necessary or used for compacting a single briquette.

The machine is started by the movement of a lever on the right in Fig. 1 coupled to a belt shifter. In this movement a spring shown above the main frame in Fig. 1, is compressed. When the required number of blows have been delivered this spring is released, and the belt is again transferred to the loose pulley.

The counting device and striking gear are shown in detail in Fig. 5. The arrangement consists essentially of two spur wheels, one, A, having 10 teeth on which the projecting pin of the seventh chain strikes as above described. A single-toothed pinion B is attached to this wheel and engages with a second spur wheel C having 16 teeth, placed towards the back of the machine. After each tenth stroke given by the hammers, therefore, the single-tooth pinion B moves the wheel C forward one pitch. A $\frac{1}{4}$-in. hole is drilled through the disc of C.

At a point in the belt-shifting rod directly opposite the counting mechanism is a circular steel locking pin or bolt G, $\frac{1}{4}$-in. diameter, fixed so as to be parallel with the shifter bar. This pin is a sliding fit in two holes, one of which as already mentioned is in the wheel C, while the other is in the bracket by which the spur wheels are carried; before the machine is started up the normal position of the pin is in these two holes. On throwing over the belt the pin is withdrawn from these holes in the counting device, and thus unlocks it.

The withdrawal of the pin, however, does not immediately release wheel C owing to the position taken up by the single toothed pinion B when the machine is stopped. It is necessary, therefore, when starting up to hold the starting lever over until the first set of blows has been delivered. The movement of B which then takes place completely unlocks wheel C which is turned by the upward movement of rack F, Fig. 5. The starting lever may then be left in position. The rack has 17 teeth, and its movement is limited by two stops at E. It is pulled upward by means of a weight to which it is attached by a light wire passing over a pulley.

During the working of the machine the rack is worked downwards by the revolution of wheel C. A small brake acts upon a flat portion of the rack; the pressure which this exerts is momentarily removed by the starting lever when it is pushed over, and the rack thus freed rises and revolves wheel C into the starting position after it has been unlocked by the pinion B as already described. When the starting lever is released by the operator the brake again acts upon the rack, preventing any movement other than that due to the revolution of wheel C. When this wheel has been turned into the starting position, the position of the hole in it no longer corresponds with that of the hole in the bracket, and the locking pin can no longer pass through both. They do not again coincide until after 120 blows have been delivered by all the hammers. When again fair the locking pin is pulled through them by the action of the spring, the belt being also transferred to the wire loose pulley.

To prevent any damage to the machine due to accidental displacement of the wheel A, a registering pointer has been added to indicate the position which the marked tooth on wheel A should occupy when the machine is started. A ratchet and pawl prevent any backward movement of the shaft due to the weights.

The base is very solidly built of concrete to minimise vibration and withstand the shock of the hammers. The right-hand end is made somewhat lower to provide for the device used for clamping cube moulds.

The method of retaining the moulds and dies in position under the hammers is as follows:—The six moulds each on a thin pallet are arranged in approximately the correct position on a thick iron base plate guided between the two main wooden standards. Two screw clamps passing through the standards hold the base plate in position.

Resting on top of the moulds and clamped firmly in contact with them by a screw at each end of the base plate, is an iron cover plate, having in it six holes of shape, and size, corresponding with the openings in the moulds beneath. On the under-side of this cover are registering pins, corresponding with holes in the moulds. The true alignment of the dies with the hammers is ensured by a registering bar and stops affixed to the frame of the machine and the cover respectively.

After tightening up the clamps, the mortar is distributed in the moulds through the holes in the cover plate, dies are placed on the mortar, and the whole pushed into position under the hammers to be held by the two screw clamps.

Since the machine was first designed, two useful additions have been made, one being an attachment for simultaneously raising the six hammers an inch or so above the dies to enable the iron base, the moulds, cover-plate and dies to be easily withdrawn. To the front of each hammer is attached a steel pin fitted with a small brass sleeve to form a roller; passing under these six rollers is a flat iron bar slung by two links from the top of the frame. On being pulled to one side by the handle on the left (Fig. 1), the hammers are raised.

The iron bar can be held in position by a spring catch at the left-hand side,

The second improvement which has proved very convenient is a cleaner, by means of which the six holes in the cover plate are cleaned at one operation. This is shown in the view, Fig. 4, and also in Fig. 1. It is attached to the under side of the shelf in front of the machine. Each of the six cleaners consists of four thin rubber pads slightly larger than the holes in the cover plate, carried on short bars, the rubber pads being separated by packing pieces $\frac{1}{16}$ in. thick. In use, the plate is simply pushed once or twice over the pads, when the holes in the plate are left practically free from adhering mortar.

Aeronautical Exhibits at South Kensington Museum.—A supplementary catalogue of the aeronautical exhibits in the Science Museum, South Kensington, has been compiled by Mr. M. J. B. Davy, and is now obtainable from any of the branches of H.M. Stationery Office, price 1s. net. It contains brief descriptive and historical notes of over 200 exhibits, including aeroplanes, seaplanes, lighter-than-air craft, aero engines, airscrews and aircraft instruments.

COMPACTING MACHINE FOR SAND-CEMENT BRIQUETTES FOR TESTING.

(*For Description see Page 273.*)

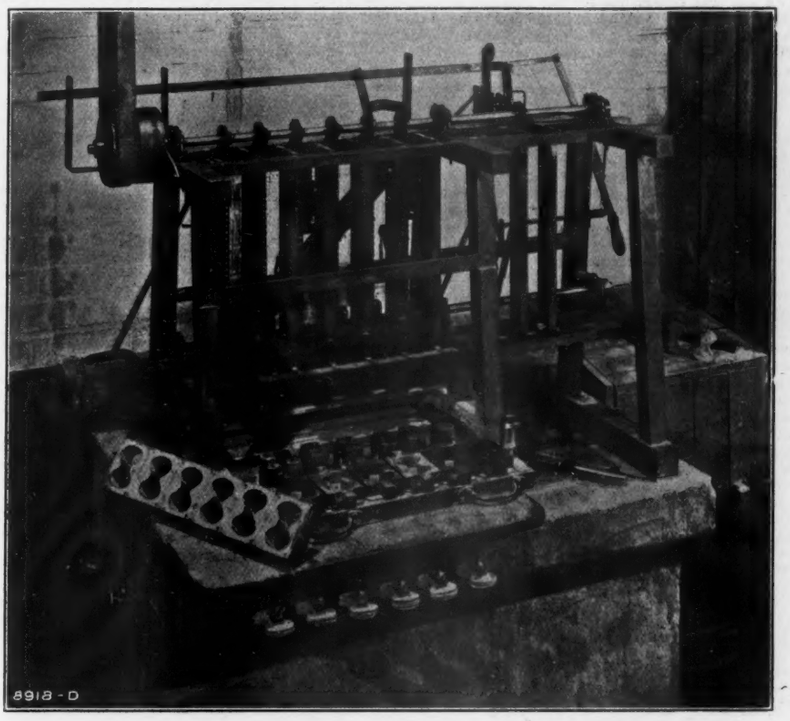
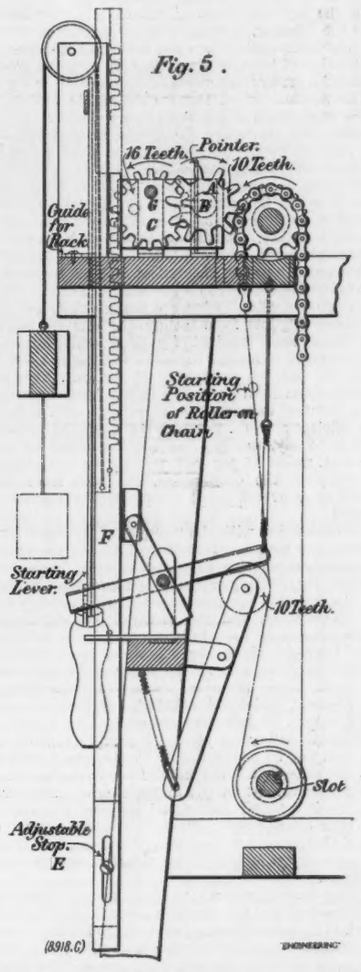


FIG. 4.



GAS FURNACES APPLIED TO THE STEEL INDUSTRY.*

By S. A. SEARS, B.Sc. (Lond.).

IN this lecture the principles of heat transference and combustion were first discussed, as well as the properties of fuels and the forms in which they are supplied to furnaces. As gas can be most easily controlled, and as its constituents can be readily determined, we have in it a fuel which has much to recommend it. We know definitely the exact amount of hydrogen and of carbon passing through the furnace per minute, and, in consequence, know the exact amount of air required for perfect combustion, with a far greater certainty than with any other fuel. All gases will mix together or diffuse if given sufficient time, but the rate of diffusion depends upon the ratio of the specific densities of the two gases, being a maximum when the ratio is unity. To attain maximum flame temperature it is essential for the combustion to be as rapid as possible, and this means that no time should be lost owing to faulty diffusion. The correct way to supply gas fuel to any furnace is to pre-mix the primary air with the gas to form a pre-diffused mixture which has the twofold advantage of raising the specific density of the gas up to nearly unity, and also of supplying a diffused gas which will naturally take up the extra air more readily where the fuel molecules are already separated by air molecules. Any error in the proportions of fuel to air must mean an avoidable loss as, if there is an excess of fuel, this excess is heated and thrown away hot, taking with it not only its own energy, but also the extra energy it has absorbed in being heated up. An excess of air in the same way will take energy from the fuel and, therefore, will require more fuel and air to heat it up. The effect is cumulative, and even the small error of 5 per cent. will mean 10 per cent. extra fuel consumption. As these two essentials, proportion and diffusion, are of such great importance, it would be much better to equip a furnace with an apparatus which would take the control out of the operatives' hands, and give a purely automatic control which could be relied upon to act accurately under all conditions.

* Abstract of a Lecture delivered before the Sheffield Society of Engineers and Metallurgists at Sheffield University, on February 23, 1925.

Several years ago, the first successful gas and air pre-mixing apparatus was introduced, and has been in operation with great success wherever gas has been used as a fuel, and although not primarily designed for furnace work, yet in many instances it has been applied with an increase of from 10 per cent. to 25 per cent. in fuel economy. The accuracy of this apparatus is typified in its adoption by the textile industry for the gassing of yarns, which process requires a uniform and constant flame to singe the finest cotton yarns made, the essential in this application being uniformity of flame temperature, shape, size and structure, which may be repeated day after day with exact precision. Such accuracy is also desirable in the steel industry, in order to ensure identical results in the heat treatment of the delicate alloy steels from week to week.

After discussing the various means employed for controlling the supply of gas and air, the lecturer dealt with the Selas system of mechanically mixing them in pre-determined proportions by first reducing the gas pressure to zero or atmospheric pressure, and drawing both gas and air through ports which, by rotating a piston valve inside a stationary liner, can be set at any desired proportion.

The lecturer considered that the only system which definitely ensures constant and instantaneously correct proportions of gas and air under any conditions, irrespective altogether of the skill or attention of the operative, other than temperature control, is the system known as the unit control valve. The principles on which this is based are the well known laws of the flow of gases propounded by Bernoulli, and now better known as the laws of Venturi flow. The flow of a fluid through a Venturi tube sets up a difference of pressure proportional to the rate of flow. Two Venturi tubes are used, one for gas and the other for air, so designed that when the correct proportional rates of flow are set up, the differences of pressure in both Venturi tubes are the same. The two pressure differences act on two diaphragms in opposition so that, when balance is disturbed, the common spindle joining the two diaphragms moves in the direction of the greater flow. The motion of this spindle actuates a very ingenious and simple relay valve which controls the air flow and acts with great rapidity although the variation in flow may be less than 1 per cent. Both the air and gas are under pressures of a few inches water gauge, the air pressure usually being slightly in excess of the gas. The only hand operation is the regulation of the gas supply according to the desired temperature.

After passing the control valve, the air is divided into two or three channels, the primary air being delivered into the gas main through a diffusion injector which pre-mixes the primary air and gas in the desired ratio. The secondary air is delivered through the recuperative or regenerative system to the furnace chamber. Sometimes, tertiary air is also provided for. By means of this control the furnace atmosphere is kept constant and combustion is carried out at its highest efficiency, with maximum fuel economy on any particular furnace.

In dealing with furnace design, the lecturer first considered the method of fuel application, stating that fuel may be introduced under the hearth, at hearth level on either or both sides, or at the top of either or both sides, or through the roof. For low temperature processes, such as annealing, normalising, carburising, &c., the flame should not come into actual contact with the product, in which case, the underhearth system has much to recommend it, but where the product is heavy, the hearth must be strong enough to support it safely and is therefore, too thick to transmit the heat through it; in consequence, much heat would be wasted. If side firing is used, the direction of flow must be vertical to prevent flames from coming into contact with the product. In the case of higher temperatures, such as would be required in forging and high-speed alloy hardening, the flames may be used in actual contact with the product; in many instances, therefore, side or top firing are beneficial. In many of the higher class of alloy steels, the local heating and chemical effect due to flame contact is harmful and will not permit of this form of fuel application. In these special cases, high conductivity muffles are employed which are capable of standing temperatures of 1,500 deg. C. and over, without the

possibility of contact of the product with either the flame or the waste products of combustion. In this respect, the modern gas furnace gives identically similar results to the best class of electric muffle at about 25 per cent. of the running costs. In small or medium sized bar-forging furnaces, gas is supplied from the top and front of the chamber by burners over the opening, forming a flame barrage to prevent the loss of heat from the open door. In this case, the application of heat by direct contact with the product ensures far greater uniformity of temperature on the bar.

The application of the secondary air follows the above application of gas supply very closely. If at all possible, the secondary air should be screened from the product by the gas to ensure as great a factor of safety from scaling as possible. In the majority of steel furnaces, the atmosphere must be reducing, so that it would be advisable to supply tertiary air to complete the combustion after the gases have left the furnace chamber. It is found that scale is formed in a furnace chamber only when the aeration, or percentage of air present to the theoretical amount required for perfect combustion, is at some definite point below 100 per cent. according to furnace temperature, and thus, to ensure freedom from scaling, the aeration must be less than that required for hard scale formation. For example, in forging furnaces working at 1,400 deg. C. on the bars, an aeration of 85 per cent. gives practical freedom from hard scale in the furnace chamber. If a furnace were worked at 85 per cent. aeration, the efficiency would probably be down 30 per cent., that is to say, the gas consumption would be up 30 per cent. unless 15 per cent. tertiary air was employed to complete the combustion, the heat from which would be recovered in the recuperative or regenerative system.

In connection with the removal of the spent gases, the lecturer considered several points, and the question of waste-heat recovery was also dealt with. The principal systems for effecting economy and increasing efficiency in this direction involve the use of either recuperators or regenerators, and the essentials for efficiency in these appliances were fully discussed. In connection with town-gas plant, the volume of air required for perfect combustion is of the order of 80 per cent. of the total, hence the usual practice of recuperating on the air only, which simplified the proposition greatly with only a slightly less efficiency. As a rule, the additional outlay on plant for recuperation of town gas will not be warranted by the increased economy. On the other hand, the smaller percentage of air and the larger volume of gas in the case of producer gas renders it a sound commercial proposal to recuperate on both air and gas. When this is done, great care must be exercised to keep the air and gas flues isolated to prevent loss of heat by pre-ignition, caused through leakage.

After dealing generally with some typical examples of furnaces for low, medium, and high-temperature work in the heat-treatment of steel, the lecturer referred to the use of gas furnaces in the auxiliary branches of the steel industry for such purposes as rivet heating, tyre heating, &c., finally giving some useful information on the question of running costs. A battery of three furnaces, he stated, which were originally fired with solid fuel and worked for 140 hours per week, consumed 26 tons of fuel per week, half coal and half coke—average cost, say, 30*s.* per ton, or 39*l.* per week. Three men were employed in wheeling coal and ashes and stoking—that is, one man per shift, their wages amounting to 10*l.* and making the total working cost 49*l.*

These same three furnaces are now worked with cold, clean producer gas, consuming 6,000 cub. ft., or 9 therms per hour, each. The actual cost of this gas is 4·75*d.* per 1,000 cub. ft., or 3·17*d.* per therm, which, for the same output of 140 hours for three furnaces, amounts to 49*l.* 17*s.* 6*d.* The advantages are: no labour, greater cleanliness and control, floor space saved sufficient to install double the number of furnaces, and reduced repairs. In comparing the figures of the older types of gas furnace with the latest designs under scientific fuel control, the lecturer taking an average of very many furnaces, found that a saving of 17 per cent. has been effected by altering the design and installing scientific fuel control. In this figure the further economies resulting from the addition of recuperators to many non-recuperative furnaces are not included.

AUSTRALIAN TARIFF.—Sir Joseph Cook, the High Commissioner for Australia, has been advised by the Commonwealth Government that under the new conditions of Preference which are to operate from April 1, 1925, classes of goods, such as motor-car chassis not made in Australia, will be admitted at preferential tariff rates, irrespective of the origin of the material used therein provided United Kingdom labour or material, or a combination of both, represents at least 25 per cent. of the factory or works costs of the article.

SUBMARINE ENGINES AND HEAVY-OIL ENGINE ELECTRIC GENERATING SETS.*

By P. A. HOLLIDAY.

THE war was responsible for the greatest developments that have yet taken place in the perfecting of the high-speed Diesel engine. The most prominent arose from the demands of the submarine service, and this was especially so in the case of Germany. In this country we had little evidence of any marked departure from the mechanical injection, 100 brake horse-power per unit cylinder submarine engine. Germany had, however, produced ten cylinder engines rated at 3,000 brake horse-power and 390 r.p.m., and six-cylinder 1,750-brake horse-power engines of the same unit design were actually afloat. Of the various makes and types of engine that came into our possession at the Armistice, it is proposed to deal chiefly with the four-stroke cycle engine as designed by the M.A.N. Company, firstly, because it bears the strongest family likeness to a stationary engine, and secondly, because it was regarded as the "star turn." Of the two-stroke cycle design with cylinder head scavenger valves, it is safe to say that it offers little encouragement to the designer in these days of port scavenging, and is now regarded as an obsolete type.

The engines it is proposed to examine have six cylinders with air injection of the fuel. The air compressor is driven direct at the forward end of the crank-shaft and has either three or four stages of compression. This range of engines covers maximum outputs of 300, 550, 1,200 and 1,750 brake horse-power. Table I gives the leading particulars of the engines as designed for boat service, and Table II gives some comparative figures relating to successful engines adapted for land stations.

TABLE I.

—	*a.*	*b.*	*c.*	*d.*	*e.*
Brake horse-power of engine	300	550	550	1,200	1,750
Cylinder diameter in inches	10·24	13·78	12·8	17·72	20·86
Piston stroke in inches ..	14·17	13·98	16·54	16·54	20·86
Revolutions per minute ..	450	450	450	450	380
Mean piston speed in feet per minute	1,063	1,050	1,240	1,240	1,320
M.E.P. on B.H.P. basis, lb. per square inch ..	75·5	77·5	76	86·3	88·8
M.I.P. with 75 per cent. mechanical efficiency, lb. per square inch	100·5	103	101	115	118
B.H.P. per square inch of piston area	0·607	0·616	0·710	0·810	0·855

TABLE II.

—	*c.*	*d.*	*e.*
B.H.P. of engine	440	800	1,075
Revolutions per minute	375	375	275
Mean piston speed in feet per minute ..	1,035	1,035	955
M.E.P. on B.H.P. basis, lb. per square inch	73	69	75·5
M.I.P. with 75 per cent. mechanical efficiency, lb. per square inch	97·3	92	100·5
B.H.P. per square inch of piston area ..	0·567	0·54	0·525

In the tables engines (*a*), (*b*), (*d*) and (*e*) are of M.A.N. design; (*c*) is a Koerting design.

Comparing the particulars given in Tables I and II with similar particulars taken from the general run of engines in use by members of the association, it will be observed that the horse-power rating per square inch of piston area is greater in the case of these high-speed engines, even after they have been reduced to a comfortable commercial rating. An average figure for English-built four-stroke cycle Diesel engines would be round about 0·43 brake horse-power per square inch of piston area, although a recent case of a high-speed engine gives 0·735. These reconditioned, so-called high-speed engines, running in satisfactory and efficient commercial use, are giving about 25 per cent. more power per unit of cylinder area than members have been accustomed to.

That is interesting in that it affords proof of the practicability of the quick-running heavy-oil engine for the purpose of electric generating stations, with its lower first cost and considerable smaller dimensions in comparison with the conventional type of engine for use on land. In these days of high cost of land and buildings, it is worth noting that the Leigh-on-Sea substation building, which was erected before the war for a possible installation of five 300-brake horse-power medium-speed engines, making a total of 1,500 brake horse-power, has already been equipped with four of these ex-submarine engines having a total brake horse-power in service there of 3,800 brake horse-power, with space left for a further 1,100 brake horse-power, the total ultimate capacity being 4,900 brake horse-power. Further than this, it would have been possible to instal five 1,100-brake horse-power engines with a total capacity of 5,500 brake horse-power, as against the total capacity of 1,500 brake horse-power first contemplated. With slight modifications to foundations originally intended for a 300-brake horse-power engine and dynamo it has been possible to erect an engine of 800 brake horse-power driving a tandem submarine generator.

To obtain greater powers per unit of cylinder area for any given cycle of operations, the designer has the choice of adopting higher piston speeds, increasing the mean indicated pressure, or improving the mechanical efficiency of the engine. In their submarine engines the Germans used relatively high piston speeds and mean pressures. As applied to land use, the engines installed by the firm with which the author is associated use a mean indicated pressure within the region 95 lb. to 100 lb. per square inch, this being the usual range for land type engines. Advantage has been taken of the possibility of running with higher mean piston speeds than those usually adopted, but not up to the maximum for which the engines were designed.

Greater piston speeds or higher M.I.P., whilst contributing to increased horse-power per unit of cylinder area, also create the need for more attention being paid by the designer to the question of heat flow owing to the burning of additional fuel expressed in pounds per square inch of piston area. It is known that heat problems are related to this value, and if progress is to be maintained the designer and the metallurgist must collaborate with a view to making possible the adoption of higher values than have been obtained hitherto. That relatively high values of the fuel/piston area ratio can be met, is proved by the design of submarine engines and certain types of the two-stroke cycle engine.

Twenty years ago Diesel engines were being built which had a fuel consumption of about 0·165 lb. per square inch of piston area per hour, and engines are still being manufactured which show at the most 7 per cent. to 10 per cent. increase on the figure. Values of 0·350 to 0·365 are obtained with the maximum ratings of the submarine engine, or, roughly, twice the usual present-day practice in four-stroke cycle engines. When installed as stationary engines the value is brought down to 0·256, a distinct advance on common practice.

TABLE III.

Type of Engine.	B.Th.U.'s per square inch of PistonArea per Hour.
Two-stroke cycle, opposed-piston gas engine	6,100
Four-stroke cycle, tandem gas engine..	3,300
Four-stroke cycle, horizontal, slow-speed gas engine	3,200
Two-stroke cycle, opposed-piston heavy-oil engine ..	5,000
Two-stroke cycle, single-acting, heavy-oil engine ..	5,750
Two-stroke cycle, double-acting, heavy-oil engine (Worthington)	6,200
Four-stroke cycle, single-acting, heavy-oil engine (land type)	3,300
Four-stroke cycle, single-acting, heavy-oil engine (marine type)	3,000
Four-stroke cycle, double-acting, heavy-oil engine..	4,300
Four-stroke cycle, submarine-type engine (British)	4,700
Four-stroke cycle, submarine-type engine (German)	6,700
Four-stroke cycle, ex-submarine-type engine (Leigh sub-station)	4,600
Four-stroke cycle, solid-injection, horizontal engine	3,250
Two-stroke cycle, crank-case compression, scavenged, hot-bulb engine	3,500
Four-stroke cycle aero engine (Maybach)	14,400
Four-stroke cycle aero engine (English)	10,400

Lest it should be considered that the engines referred to are very heavily rated, Table III has been prepared giving a list of various types of internal-combustion engine, comprising gas, heavy-oil and petrol, and the value of the fuel burnt per square inch of piston area expressed, for the sake of uniformity, in British thermal units.

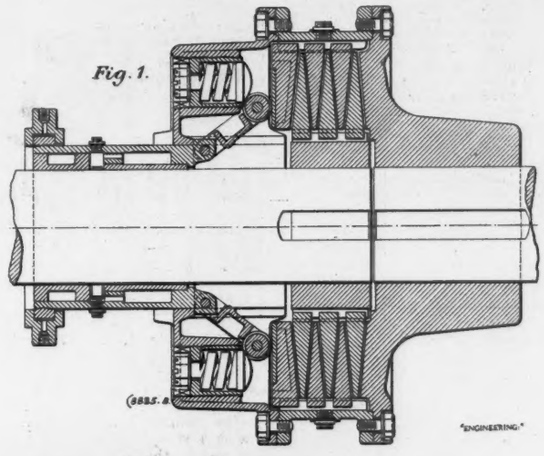
* Abstract of Paper read at the Meeting of the Diesel Engine Users Association on Friday, February 13, 1925.

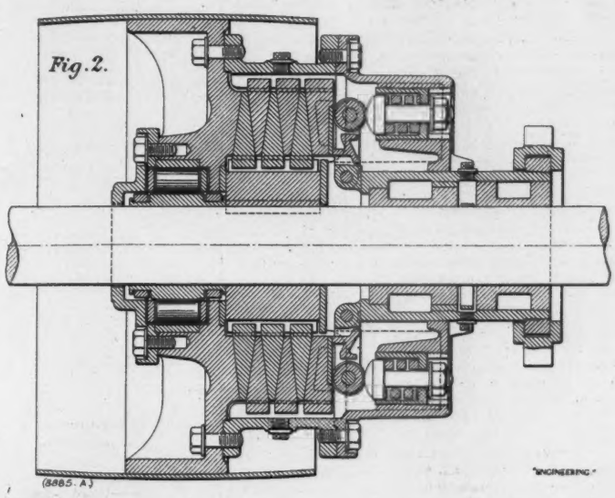
THE OPTICAL SOCIETY.

IN his Presidential address to the Optical Society on Thursday, February 12, Professor Archibald Barr referred to the optical instrument maker as the tool-maker for all branches of scientific investigation, including his own. Scientific investigators depend to a great extent on the knowledge and skill of the optician for the provision of the tools that enable them to carry on their work. Every improvement made in the optician's products enabled the use of these tools to go farther and deeper in his researches. Were the optician to produce a telescope or a microscope of much greater power than the best hitherto obtainable, a flood of new discoveries would be immediately announced. Vision was the faculty upon which, directly or indirectly, all scientific work and very much of our ordinary occupation depended, and the function of the optician was to provide more and more

FRICTION CLUTCH FOR SHAFT COUPLINGS AND PULLEYS.

CONSTRUCTED BY THE COOPER ROLLER BEARINGS COMPANY, LIMITED, ENGINEERS, KING'S LYNN.





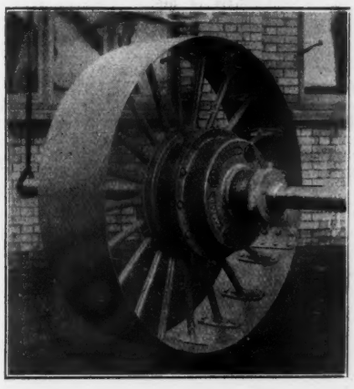


FIG. 3.

delicate and powerful means for increasing its effectiveness. It was the duty of the optician to keep himself familiar with the latest advances in science, so as to be ready to forestall the needs of the investigator, or to be able fully to understand the requirements that arose, and to bring to bear on the production of the new tools an intimate knowledge of the means by which, and the extent to which, the requirements could be fulfilled in a practicable device.

Optics was a part of the science of radiology which had been so surprisingly extended in recent years along the wide range of vibrations from beyond the X-rays to those of the long waves involved in wireless telegraphy and telephony. Opticians were primarily concerned with less than one octave out of the sixty or more, though for some purposes they had to take account of one or two octaves on each side of that of visability, into the infra-red and the ultra-violet. Narrow as it might be on the scale of radiology, the one octave of the visible spectrum had, and always would have, a very special significance in the scheme of things as they were, and that octave included a wide range of problems of all degrees of complexity. Within the limits of optics properly so called there was still scope for development to which no limits could be set.

THE COOPER FRICTION CLUTCH.

THE illustrations, Figs. 1, 2 and 3, on this page show the details of a friction clutch made at the King's Lynn works of the Cooper Roller Bearings Company, of 56, Cannon-street, London, E.C.4. Two designs are shown, the first, Fig. 1, is suited to coupling two shafts in line, while the other, Figs. 2 and 3, is of the pulley type.

Referring first to Fig. 1 it will be seen that the clutch is made up of convex and concave plates, arranged alternately. These have slots at their thick edges, which engage with keys either on the cover, which is connected to the one shaft, or on a driving boss located on the other. As these plates are free to slide along the keys they may be pressed together or separated at will. Opposite the set of plates, and situated in the cover, there are heavy springs, which are used to keep the plates in absolute contact when the clutch lever is put over into the "on" position. Associated with each spring there is a ram with a rounded head. The intermediate link between these rams and the friction plates consists of a series of small rollers mounted on the ends of hinged arms, which have their other ends centred on a sleeve which can be moved in and out of the cover. These hinged links are arranged to slide within slots in the cover and are therefore always in the correct position for immediate operation. Each set of rollers on the links consists of two plain ones on the outside, which press against the clutch plates and a middle one formed with a hollow groove in it which rests on the curved head of the spring-held ram. The clearance between cover and sleeve is small, and a self-oiling bearing is provided for the sleeve which comes into operation when the clutch is disengaged. The arrangement of this bearing is such that it ensures an ample supply of oil being given to the bushes, whenever there is relative motion between the clutch and the shaft.

On the outside of the sleeve, at the exposed end, there is a yoke ring provided with trunnions and by means of these the motion of the operation lever is conveyed to the sleeve to put the clutch on and off. When the sleeve is forced in, the plates come into actual contact and the setting in this position is that depicted in the illustration of the type of clutch shown in Fig. 2. The springs, compressed initially to give the required load, are housed in cylindrical boxes and the rams which come into contact with the rollers are extended through the springs to the outside of the boxes and provided with nuts on their ends to limit the expansion of the springs. The plates are released immediately the pressure is taken off these springs. Adjustment is effected by pushing the sliding sleeve into the engaged position and screwing in the spring boxes until the nuts on the ram spindles are lifted off their seats. This operation, which is exceedingly simple may be performed in a few minutes without dismantling any part of the clutch.

In the pulley type of clutch, the back cover is fitted with a Cooper roller bearing, fixed in position on the centre line of the pulley. This takes the pull of the belt and its presence reduces wear and tear in the clutch. Gun-metal rings fixed on the clutch and running against the ends of the driving boss are used to ensure the location of the clutch on the shaft at all times. These are all the changes that are made in the design to meet the altered conditions of use when the clutch is fitted to a pulley. The construction when the pulley is built up on the cover is shown in Fig. 2, while Fig. 3 depicts the alternative arrangement of bolting it to the pulley.

These clutches are standardised for use with electric motors, steam, gas or oil engines and all classes of machinery. They are peculiarly suited to cases where the driving mechanism is required to take up a heavy load slowly and smoothly. At present they are in use transmitting up to 700 brake horse-power at 300 r.p.m. but larger sizes, for up to 2,000 brake horse-power at 100 r.p.m. can be supplied.

THE MANUFACTURE OF CARBON BLACK.

ACCORDING to a recent official report, the possibility of manufacturing carbon black from oils by an electrical process, which possesses advantages over the methods of securing this important industrial material from the incomplete combustion of natural gas, has been demonstrated as a result of experiments conducted by the United States Department of the Interior, at the Pittsburgh Research Station of the Bureau of Mines. Carbon black is a finely divided, sooty pigment obtained by causing the yellow flame of methane, or natural gas as it is often called, to impinge while burning with an insufficient supply of air against a cool metal surface. The substance is of wide utility, being employed in the making of printers' inks, automobile tyres, stove and shoe blacking, gramophone records, black leather, typewriter ribbons, carbon-copy and photograph papers, &c. The importance of these from the industrial point of view will be manifest and great interest attaches to the experimental work in progress. In the course of investigating the effects of high-voltage electrical discharges through hydrocarbons it was noted by the chemists of the Bureau of Mines that under certain conditions natural gas could be decomposed and carbon black produced. The effects of these changes were then studied. The object aimed at in the case of natural gas was to secure the recovery of a larger part of the carbon content of the gas than is now possible by other methods.

In the commercial manufacture of carbon black from oils by the arc process developed by the Bureau of Mines, the two principal requirements are cheap electric power and light oil distillates. It is suggested that since the process is suitable for intermittent operation some of the large supplies of cheap off-peak power available in many localities throughout the world could be utilised. The advantage of manufacturing the material where it is actually required also possesses obvious advantages. It is thought that the unsaturated gases produced during the decomposition of the oil might constitute a profitable source of by-products if utilised for the manufacture of alcohols. Also gases formed in connection with the process were suitable for domestic fuel and could probably be sold in localities where a market existed for house gas, and this would reduce the total cost of producing carbon black.

About 25 per cent. of the present output of carbon black in the United States is used in printing and allied trades. The rapid growth of the automobile industry has created an extensive market for carbon black as a toughening agent in rubber, since the addition of the material as a reinforcing agent gives greater elasticity and tensile strength. The mileage obtainable from tyres so treated is said to have been increased by 20 to 30 per cent. About 20 per cent. of the U.S. production is exported, large quantities going to England, France and Germany for rubber compounding and being sent to Japan and China for ink, paint and enamel manufacture. Full particulars regarding the experiments of the Bureau of Mines are given in Technical Paper 351, which may be obtained (price 6*d.*) from the Superintendent of Documents, Government Printing Offices, Washington, D.C., U.S.A.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

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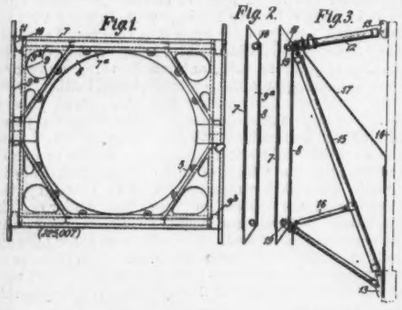
AERONAUTICS.

225,007. H. Bolas, Bristol, and G. G. Parnall, Bristol. Aircraft Engine Mounting. (6 *Figs.*) September 27, 1923.—The invention has reference to an improved engine mounting for aircraft. The invention consists of an improved engine mounting with a girder type of engine plate, wherein the engine and front section of the cowling can be mounted as a complete interchangeable unit, the engine plate being supported by means of a rigid triangulated stay structure having pivotal connection with the fuselage of the aircraft. The engine plate is formed as two rectangular plates 7 and 8, the front plate 7 of which is formed with an hexagonal aperture 7a and the rear plate 8 to which the engine crank-case is bolted is formed with a circular aperture. These plates 7, 8 are spaced apart and braced by a plurality of channel-section strips 9 riveted to the plates 7, 8, the assembled engine plate thus constituting a girderlike framework. The front plate 7 and/or the rear plate 8 is, or are, preferably lightened by cutting away parts thereof as is clearly seen in Fig. 1. The vertical sides of the plates are secured to, and spaced apart by, channel section bars 9a, which are greater in length than the sides of the plates. These bars 9a are formed adjacent their ends with circular apertures 10, and the plate 8 is formed with slots 11 near each corner thereof, the bottom of these slots being reinforced. The supporting structure for the engine plate comprises two pairs of inclined tubular stays 12 which are pivotally connected at their rear ends to brackets 13 adapted to be secured to the fuselage 14. These stays 12 are positioned by means of a pair of diagonally disposed tubular struts 15 which are pivotally connected at their upper end to the upper pair of stays 12 adjacent the



front ends thereof and at their lower end to the bottom pair of brackets 13, the whole structure being maintained in a rigid condition by means of short tubular struts 16 connected to the lower pair of the stays 12 adjacent the front ends thereof and to the diagonal struts 15 intermediate the ends thereof, additional bracing being provided by means of wires or cables 17 connected to the fuselage. The front ends of the stays 12 are provided with eyed lugs, the eyes of which are adapted for register with the apertures 10 in the channel bars 9a. The eyed lugs are inserted in the slots 11 of the engine plate and so brought into register with the apertures 10 when bolts 18 are passed therethrough and secured by nuts 19 whereby the engine plate is firmly attached to its supporting stay structure and hence to the fuselage. The back plate of the engine crank-case is bolted to the rear plate 8, or to an adapter plate secured thereto, and hence, as the auxiliary parts of the engine, such as the carburettors and magnetos, are bolted to the engine crank-case, it is only necessary to disconnect the fuel and oil feeds and like connections, and the bolts 18 securing the engine plate to the stay structure, when the engine may be removed as a unit and a like engine or other standardised engine substituted therefor. The front part of the engine cowling (not illustrated for the sake of clearness in the drawings) is connected to the engine plate in any convenient manner and is removable in its entirety with the engine. The rear part of the cowling surrounds the triangulated stay structure, the two parts of the cowling, when the engine is in position, being spaced apart but interconnected by means of toggle clips which prevent accidental unfastening of the panels constituting the two sections of the engine cowling. (*Accepted December* 3, 1924.)

LIFTING AND HAULING APPLIANCES.

224,380. Henry Simon, Limited, Manchester, and H. Atherton, Manchester. Band Conveyors. (8 *Figs.*) November 8, 1923.—The invention relates to band conveyors and comprises the combination with the band conveyor, on to or from which the grain is dumped or delivered, of a fan or exhauster rotated by one or more rollers driven by frictional contact with the conveyor in association with a dust-collecting hood arranged adjacent the point of dumping or delivery, and with dust-separating means. A frame *a* is carried by the framework *b*, which supports the guide roller *c* for the conveyor belt *d*. The frame *a* supports the bearings for a shaft *e* having thereon the roller *f* beneath the conveyor belt *d* and a belt pulley *g*. It also supports the bearings of a shaft *i*, on which is a roller *j* which rides on the top of the belt *d* above the roller *f*.

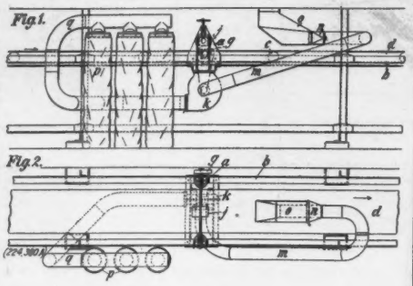
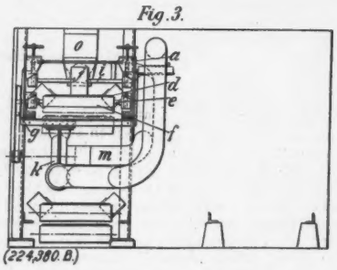


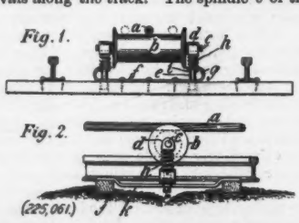
Fig.3.



The pressure exerted on the belt *d* between the rollers *f* and *j* can be varied. The fan or exhauster *k* is suspended from the frame *a* beneath the lower stretch of the conveyor belt and is rotated from the belt pulley *g*. The fan acts through the conduit *m* to exhaust dust from the hood extension *n* of the spout or shoot *o* through which grain is dumped on to the conveyor belt *d*. The dust-laden air is delivered by the fan into the bags or dust separators *p* through the conduit *q*. The frame *a* can, if desired, be moved lengthways along the girders *b* to adjust the position of the exhaustion apparatus to suit requirements. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

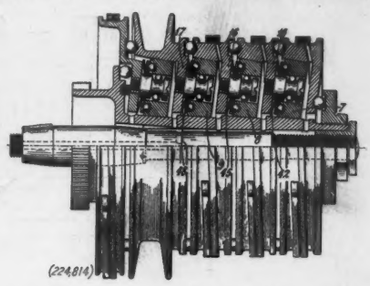
225,061. T. J. Thomas, Maesteg. Colliery Trams. (5 *Figs.*) November 29, 1923.—The invention relates to guide rollers and sheaves for the main-haulage ropes and, in some cases, also for the tail-haulage ropes of colliery trams. According to the invention, the guide roller or sheave is spring mounted so as to be capable of yielding towards the support when subjected by the haulage rope to excessive pressure. *a* is the main haulage rope and *b* is the usual guide roller for the rope provided at intervals along the track. The spindle *c* of the roller



b is journalled in eyed heads *d* formed at the ends of plunger stems *e* guided vertically in holes formed in an iron base plate *f* and in the in-turned and inwardly overhanging ends *g* thereof. Helical springs *h* are threaded on each plunger stem *e* and interposed between the heads *d* thereof and the in-turned ends *g* of the base plate *f*. Thus, the journal bearings of the roller *b* and, consequently, also the roller *b* itself, are spring-supported and can yield to an excessive downward pressure exerted by the main-haulage rope *a*, for instance at the brows of declivities. (*Accepted December* 3, 1924.)

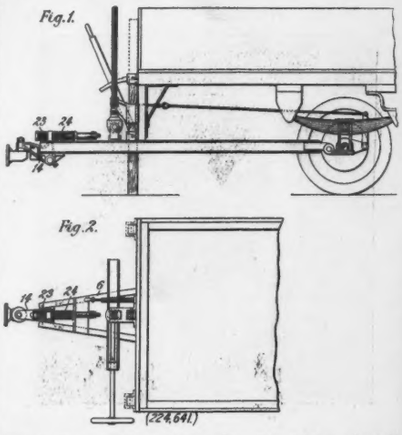
MOTOR ROAD VEHICLES.

224,814. G. M. Cameron-Cowburn, Gosport. Change-Speed Gearing. (1 *Fig.*) April 29, 1924.—The invention has reference to epicyclic, or sun and planet change-speed gearing of the friction type. The invention comprises the combination with epicyclic change-speed gearing of the friction type, as claimed in the specification of Letters Patent No. 203,511, of resilient means 42, 45 or 48 to act independently on each of the planet members 7, 8 or 9 of the sets of gearing and force them into contact with the co-operating members of the gearing. Further, in such epicyclic change-speed gearing, the sun member, planet members and the enveloping brake member of each set of gearing are conical and of such conicity that they have a common apex;



the several sets of gearing also have a common apex. In carrying out the invention, the resilient means comprise springs which are interposed between the planet members and the adjacent face of a plate 15, 16 or 17 carrying the said members. (*Sealed.*)

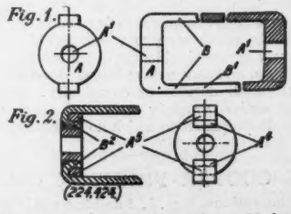
224,641. The Eagle Engineering Company, Limited, Warwick, and R. G. Pulmer, Warwick. Two-Wheel Trailers. (3 *Figs.*) September 4, 1923.—The invention consists of a two-wheel trailer character-



ised by the provision of a draw-bar 14, which is pivotally connected to the draw frame 6, the said draw-bar having a universal coupling with the tractor vehicle and opposed spring connections 23, 24, to the frame of the trailer.—(*Sealed.*)

RAILWAYS AND TRAMWAYS.

224,424. G. H. Cowen, Sheffield. Drawbar Springs. (4 *Figs.*) February 7, 1924.—The invention relates to cradles or housings of springs intended to minimise the shock on the draw-bars of railway wagons. The parts A represent end members which form abutments for the springs which are compressed by the draw-bars, one of which (when two springs are used in the same housing) passes axially through the holes A^1 at each end of the cradle. Such end members are usually of circular form in elevation, as shown in the left-hand portion of Fig. 1, so as to accommodate the ends of spiral springs, rubber buffers or the like resilient devices. The parts B are the side members, one of which is shown in section in the broken away part.



These side members are generally welded together in some part of their length at B^1, for instance, and it will be understood that such a welded construction cannot be so strong as if the metal had not so been treated. Fig. 2 shows an end elevation and a central section of an end member of an embodiment of the invention wherein slots, as A^4, or they may be pockets, are formed so as to produce bars of metal, as A^5, to receive the curled or hooked ends, as B^2, of the side members shown in the left-hand portion of the figure. Autogenous welding may be applied to the joints between the side and end members, even to the extent of filling up such grooves or only for the purpose of securing the whole together. (*Sealed.*)